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OF THE

DISEASES OF THE EAR.

ARRANGED IN THE FORM OF

QUESTIONS AND ANSWERS.

PREPARED ESPECIALLY FOR

Students of Medicine and Post-Graduate Students.

BY

E. B. GLEASON, S.B., M.D.,
CLINICAL PROFESSOR OF OTOLOGY, MEDICO-CHIRURGICAL COLLEGE, PHILADELPHIA; SURGEON IN CHARGE OF THE NOSE, THROAT,
AND EAR DEPARTMENT OF THE NORTHERN
DISPENSARY, PHILADELPHIA.

SECOND EDITION, REVISED AND ENLARGED.

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TO

PROF. B. ALEX. RANDALL,

AS AN EXPRESSION OF GRATITUDE FOR HIS VALUABLE
INSTRUCTION IN OTOLOGY

AND

FOR HIS MANY ACTS OF KINDNESS,

THIS LITTLE BOOK IS AFFECTIONATELY INSCRIBED

BY

HIS FRIEND AND FORMER PUPIL,

THE AUTHOR.

PREFACE TO THE SECOND EDITION.

It should be borne in mind that this little volume was written to aid a graduate or under-graduate student to acquire with as little reading as possible those rudiments of Otology essential before beginning ward class work in an ear dispensary; and the form of question and answer has often aided the author in his endeavor to render the text as concise and lucid as possible.

That quiz compends are sometimes used as a means of "brushing up for examination" is probably lamentable, but, when written for that purpose, "the responsibility of their production rests not with the author nor the publisher, but with the existing examining bodies" (review of first edition in *Birmingham Review*, Birmingham, Eng., January, 1895). The training of his judgment and the skill of eye and hand that a student can acquire in a properly conducted ward class by actual work in an ear dispensary are of much more practical value than any knowledge to be obtained by reading books or listening to lectures; and it is certainly lamentable that the student's otological knowledge is often judged solely by his ability to describe pathological conditions that he is incapable of recognizing and therapeutic manœuvres that he is incapable of performing.

The text of the first edition remains practically unchanged, but numerous additions have been made, especially in regard to the newer surgical procedures; especial care has also been taken to state clearly the applicability of each procedure, and what advantage to the patient, if any, can reasonably be expected to result from its performance. Where a modern otological operation has been developed from an older surgical procedure, the history of the subject is briefly stated.

A number of new illustrations have been added to those of the first edition, most of them being made from original drawings of specimens belonging to the author. The fact that medical students rarely open the human ear in the dissecting room has received attention, and directions are given for making sections through the ear in such a manner as to display to the greatest advantage the anatomical peculiarities that are of pathological or surgical interest.

E. B. GLEASON.

41 SOUTH NINETEENTH STREET,
PHILADELPHIA, October, 1897.

PREFACE.

THIS little book has been written mainly for physicians who may desire to take a post-graduate course in Otology, in order to enable them, with as little preliminary reading as possible, to acquire the rudimentary facts of Otology which are essential to appreciate properly what is seen and heard in the actual work of an ear dispensary. For this purpose a quiz-compend is undoubtedly of greater value than is a large text-book, no matter how great is the excellence of the latter.

The book is also designed to supplement the necessarily brief course of lectures that undergraduates receive in Otology, and to serve as a manual of reference during the period of their practice-work in the dispensary.

The effort has been made to state the Essentials of Otology concisely, without sacrificing accuracy to brevity. The diagnosis and treatment of diseases of the Ear have been simplified as much as possible, and in most instances the Author has contented himself with only stating the treatment which in his personal experience proved most efficacious in the majority of cases, without in every instance acknowledging the source from which the plan of treatment was originally derived.

The Author wishes, however, to express his indebtedness to the standard manuals and text-books of Otology, and to the writings of the numerous authors found in current medical literature, for aid afforded in the preparation of this little volume, and also to his assistant, Dr. E. A. Crueger, for the proof-reading and the preparation of the Index.

41 S. NINETEENTH STREET,
September, 1894.

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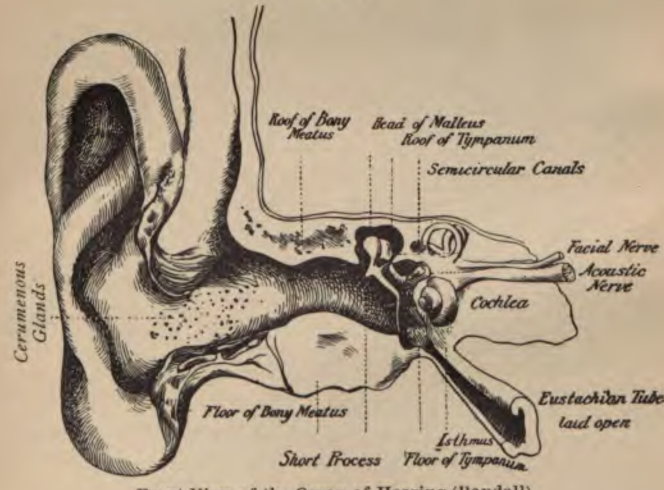
ESSENTIALS OF DISEASES OF THE EAR.

ANATOMY OF THE EAR.

Into what anatomical parts is the ear divided for convenience of study ?

The *external* ear, comprising the auricle, or pinna, and the external auditory canal; the *middle* ear, comprising the membrana tympani, cavity of the tympanum, the mastoid cells, and the Eustachian tube; the *internal* ear, or labyrinth, comprising the vestibule, the semicircular canals, the cochlea, and the auditory nerve (Fig. 1).

FIG. 1.

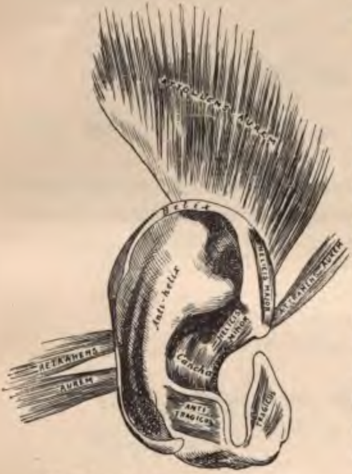


Front View of the Organ of Hearing (Randall).

Describe the auricle or pinna.

The auricle is an irregular mass of reticular cartilage deficient at certain parts, where it is connected by fibrous tissue and muscles (Fig. 2). The cartilage is covered by perichondrium, outside of which is firmly-adherent skin, containing sweat and sebaceous glands.

FIG. 2.



Muscles of the Pinna (Gray).

Mention the names given to the elevations and depressions of the pinna.

Helix, antihelix, fossa of the helix, fossa of the antihelix, tragus, antitragus, concha, and lobule (Fig. 3).

Name the muscles of the auricle.

Those on the *anterior* surface are the tragicus, the antitragicus, the helix major, and the helix minor. Those on the *posterior* surface are the transversus auriculæ and the obliquus auriculæ. Those which connect the auricle with the side of the head and move the pinna as a whole are the attolens, attrahens, and retrahens aurem (Fig. 2).

What is the lobule of the ear?

The inferior, soft, pendulous part of the pinna, consisting of fat and connective tissue covered by skin (Fig. 3).

Mention the vessels and nerves of the auricle.

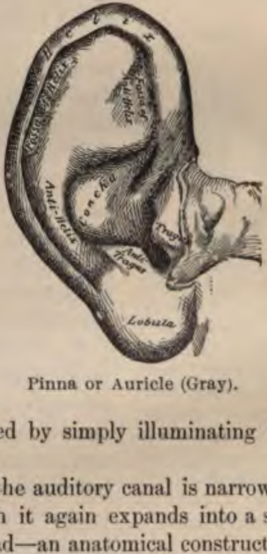
The *arteries* are the anterior auricular branch of the temporal artery; the posterior auricular artery, a branch of the external carotid; and the auricular branch of the occipital artery. Corresponding veins accompany the arteries. The posterior auricular artery is sometimes cut by "Wild's incision" through the tissues over the mastoid bone, and causes a somewhat profuse hemorrhage, which, however, is readily controlled.

The *nerves* are the auricularis magnus, from the cervical plexus; posterior auricular, from the facial nerve; the auricular branch (Arnold's), from the pneumogastric; the auricular temporal, from the inferior maxillary division of the fifth nerve; and branches from the occipitalis major and minor.

Describe the external auditory meatus.

The external auditory canal is composed of a cartilaginous and a bony portion. It is about 1¼ inches in length, the cartilaginous portion being about half an inch in length, and forming rather less than one-half the canal, which extends from the concha to the drum-head. The external auditory meatus is lined with a continuation of the skin of the auricle, which within the canal contains hair-follicles and ceruminous glands. These glands are most numerous at the junction of the cartilaginous and bony portions. The course of the canal is generally described as that of a spiral turned anteriorly inward and downward; but in some individuals the canal is so straight that the drum-head may be inspected by simply illuminating the canal by reflected light.

FIG. 3.



Pinna or Auricle (Gray).

It should be borne in mind that the auditory canal is narrowest near its central portion, beyond which it again expands into a sort of pouch terminating at the drum-head—an anatomical construction which adds somewhat to the difficulties of removing a foreign body should it penetrate beyond the narrowest portion of the canal.

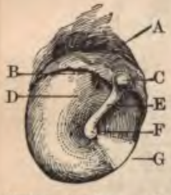
Pressure in front of the tragus usually closes the lumen of the canal; and, owing to this valve-like arrangement, the entrance of water and other foreign bodies into the canal is rendered more difficult. The most striking features of the cartilaginous meatus are the incisuræ Santorini, which completely divide the cartilage into three half rings, united by fibro-elastic tissue.

Describe the membrana tympani.

The membrana tympani is a thin, elastic membrane stretched obliquely across the fundus of the external auditory canal in such a manner that its upper and posterior portion is most external. It is divided horizontally by the anterior and posterior folds into two unequal portions—the membrana flaccida, or Shrapnell's membrane, and the membrana tensor or membrana vibrans (Fig. 4).

Shrapnell's membrane is composed of skin from the auditory canal, and of loose cellular tissue, covered by the mucous membrane of the tympanum, on its inner surface. Bridging a notch in the bony ring, the incisura Rivini, to which it is attached, it passes downward in front of the *attic*, or upper chamber of the tympanum. Between Shrapnell's membrane and the neck of the malleus is a pouch or space called "Prussak's space," which sometimes becomes distended with pus during attacks of acute catarrh of the middle ear. Under such circumstances a puncture through Shrapnell's membrane, just above the short process, will evacuate the pus contained in the Prussak space and instantly relieve pain.

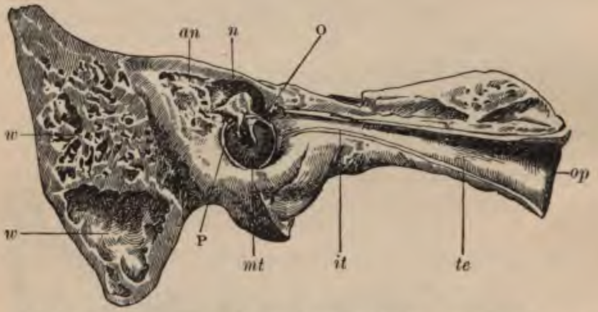
FIG. 4.



Outer surface of the Right Membrana Tympani: A, membrana flaccida or Shrapnell's membrane; B, posterior fold; C, short process; D, incudo-stapedial articulation; E, malleus handle; F, umbo; G, cone of light.

The membrana vibrans, or membrana tensor, is pearly-white in color and is polished on its outer surface. It consists of three layers—a dermic, formed by a continuation of the skin of the auditory canal; a fibrous (membrana propria), consisting of fibres radiating from a point near the centre to the circumference and circular fibres, which are so numerous at the periphery as to form a dense ring around the attached margin of the membrana vibrans, and a mucous layer continuous with the mucous membrane of the tympanum. The handle, or manubrium, of the malleus is fixed between the radiating and circular fibres of the membrana propria. The outer surface of the drum-head faces downward, forward, and outward at an angle of fifty-five degrees with the axis of the auditory canal. Its outer surface is concave. From above, the malleus handle may be seen extending downward and somewhat backward from a tubercle, its short process, and ending near the centre of the drum-head at a depression, the umbo. During life, when illuminated, the membrana tympani generally presents a triangular light spot or "cone of light," having its apex at the umbo and extending downward and forward to the periphery (Fig. 4). The mucous membrane of the inner surface of the drum-head is folded upon itself as it passes over the chorda tympani nerve, so that two pouches are formed, opening downward, one in front of, and the other behind, the manubrium (Fig. 5).

FIG. 5.



Outer Half of Sagittal Section of Entire Left Middle Ear (Politzer): O, anterior and P, posterior pouches of Von Tröltsch; *op*, ostium pharyngeum tubæ; *te*, Eustachian tube; *it*, isthmus tubæ; *mt*, membrana tympani, with the malleus and incus and the chorda tympani nerve; *n*, attic or recessus epitympanicus; *an*, mastoid antrum; *w*, *w*, mastoid cells.

Describe the vessels of the membrana tympani.

The dermoid layer is supplied with arterioles by the deep auricular branch of the internal maxillary artery; the mucous membrane by the tympanic branches of the internal maxillary, internal carotid, and stylo-mastoid arteries.

What nerves supply the membrana tympani?

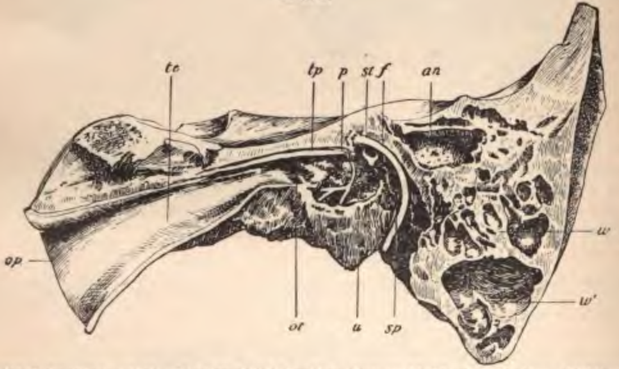
To the external layer are distributed filaments from the superficial branch of the fifth nerve, while the mucous layer is supplied by the tympanic plexus.

Describe the cavity of the tympanum.

The *cavity* of the tympanum is of irregular shape. It measures about half an inch antero-posteriorly, one-third of an inch vertically, and one-fifth of an inch transversely. It is situated in the petrous portion of the temporal bone above the jugular fossa, having the carotid canal in front, the mastoid cells behind, the auditory canal externally, and the labyrinth internally. It communicates with the pharynx by means of the Eustachian tube and with the mastoid antrum by means of the aditus ad antrum. The upper portion of the tympanum is called the *attic*, or recessus epitympanicus; the lower, the *atrium*.

The *roof* of the tympanum consists of a thin plate of bone, the tegmen tympani, which separates the tympanic cavity from the meninges of the brain. The *floor* of the tympanum is narrow, and separates the cavity of the tympanum from the jugular fossa beneath. Near the inner wall is a small foramen for the passage of

FIG. 6.



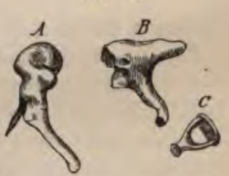
Sagittal Section of the Entire Middle Ear, Inner Half of Left Ear (Politzer): *op*, ostium pharyngeum tubæ; *te*, canalis tubæ Eustachii; *ot*, ostium tympanicum tubæ; *tp*, musculus tensor tympani; *p*, promontory, marked by the tympanic plexus; *u*, lower wall of the tympanum; *st*, stapes; *sp*, musculus stapedius; *f*, facial nerve; *an*, mastoid antrum; *w*, *w'*, mastoid cells.

Jacobson's nerve. The *outer wall* consists of the membrana tympani and the bony ring into which it is inserted. In this bony ring are two small orifices, the iter cordæ posterius and iter cordæ anterius, for the entrance and exit of the chorda tympani nerve. Just in front of and above this bony ring is the Glaserian fissure, in which is lodged the long process of the malleus, and which also gives passage to some tympanic vessels and the anterior ligament of the malleus.

The inner tympanic wall (Fig. 6), which is nearly vertical, bulges outward as an eminence, the promontory, corresponding to the first turn of the cochlea. Below, posteriorly, is the niche at the bottom of which lies the fenestra rotunda or "round window," closed by the membrana tympani secundaria. This membrane is protected by the niche, in which it so lies that it is impossible to injure it by means of a straight instrument thrust from without through the membrana tympani. Above, posteriorly, is the fenestra ovalis, or "oval window," closed by the foot-plate of the stapes. Above the oval window is the eminence of the æqueductus Fallopii, which transmits the facial nerve. The pyramid is a hollow conical projection containing the stapedius muscle, whose tendon escapes by an opening at its summit.

In the posterior wall is the opening into the mastoid antrum, the aditus ad antrum, and sometimes one or more openings into mastoid cells. The anterior wall separates the cavity of the tympanum from the carotid canal, which lies immediately below and in front of it. In the anterior wall is the orifice of the Eustachian tube. Just above is the canal for the tensor tympani muscle. The Eustachian tube is separated from the canal for the tensor tympani muscle by a thin bony plate, the processus cochlearformis.

FIG. 7.



The Malleus, Incus, and Stapes of Left Ear: A, malleus; B, incus; C, stapes.

Describe the ossicles of the tympanum.

The ossicles are three small bones so arranged as to form a movable chain connecting the membrana tympani with the fenestra ovalis. These three bonelets are the malleus, or hammer; the incus, or anvil; and the stapes, or stirrup (Figs. 7, 8).

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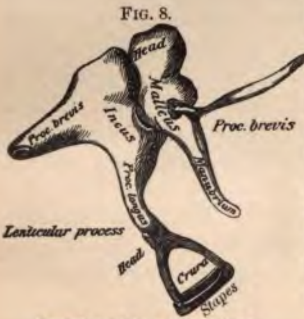
Describe the malleus.

The malleus is a somewhat irregularly-shaped bone, consisting of an oval head, articulating with the incus; a neck, a short and long process; and a manubrium, or handle, imbedded in the membrana tympani. The head and neck of the malleus, which project into the tympanic cavity, are entirely free from the membrana tympani, the surface of the head, which articulates with the incus, being directed backward. The long and short processes are situated at the junction of the neck and handle of the malleus. The short process pushes the membrana tympani outward before it, and is generally plainly visible during life as a tubercle at the upper extremity of the malleus handle. The long process passes forward into the Glaserian fissure, with the under wall of which it unites in adult life. The malleus is held in position within the tympanum by four ligaments—the anterior, superior, external, and posterior. Of these ligaments, the anterior is by far the strongest, the posterior and external ligaments being, in a mechanical sense, but one ligament, to which Helmholtz has given the name "axial ligament of the malleus."

FIG. 8.



Ossicles of the Right Ear.

Describe the incus, or anvil.

The incus is the middle one of the three ossicles, its name being derived from the shape of its upper part. This bonelet consists of a body, a short or horizontal process, and a long or descending process. The incus is attached at the extremity of its horizontal process to the posterior tympanic wall by somewhat weak ligaments (Fig. 9). The long process of the incus curves downward, and at first somewhat outward, toward the auditory meatus, its tip bending sharply inward to articulate with the head of the stapes by means of the process lenticularis.

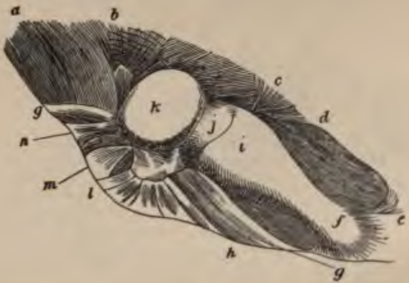
Describe the malleo-incudal joint.

The malleo-incudal joint is a ginglymus or hinge-joint, like that of the knee or elbow. The ligaments of the malleus are so arranged that the bone performs the part of a lever whose fulcrum is just below the short process. The manubrium is the long arm of the lever, and, consequently, all its movements are repeated in an opposite direction by the head of the malleus. Each inward movement of the membrana tympani and manubrium causes a slight outward movement of the head of the malleus. The incus being also suspended as a lever, when its upper part moves outward with the head of the malleus its long process swings inward and pushes the stapes before it, so that the foot-plate is forced into the oval window.

Describe the stapes, or stirrup-bone.

The stapes is the smallest bone in the body. It consists of a head articulating with the lenticular process of the incus, two branches, or crura, joining the base, which is connected by ligamentous fibres with the margin of the oval window. The stapes (Figs. 7, 8) measures 4 mm. from its head to the foot-plate, the latter measuring 2½ mm.

FIG. 9.



Ligamentous Support of Ossicles, viewed from above (Helmholtz): *l-h*, attachment of the ligamentum mallei externum; *k*, head of hammer; *i*, body of incus; *f*, point of its short process; *a*, entrance to the Eustachian tube from the tympanum; *c*, stapes; *d*, tendon of stapedius muscle; *b*, tendon of the tensor tympani leaving the cochlear process; *g-g*, chorda tympani, marking the free edge of the folds of mucous membrane bounding the pouches; *n*, the upper tendinous fibres of the ligamentum mallei anterius, originating above the spina tympanica major, *m*; *j*, malleo-incudal joint.

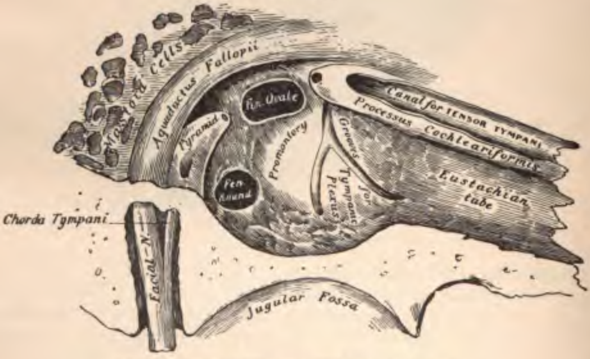
in its horizontal diameter. The foot-plate of the stapes is somewhat kidney-shaped. When in position its long axis is nearly horizontal, with its convex edge looking upward and with its concave edge looking downward. A thin membrane, the ligamentum obturatorium stapedis, stretches across the space between the base and the crura.

Describe the muscles of the tympanum.

The tensor tympani originates from the under surface of the petrous bone, the cartilaginous Eustachian tube, and its own osseous canal. It is inserted into the handle of the malleus near its root. Its action is to draw the membrana inward and increase its tension. The tensor tympani muscle is supplied by a nerve from the otic ganglion.

The laxator tympani major and minor have already been described as anterior and posterior ligaments of the malleus. The stapedius muscle originates from the interior of the pyramid (Fig. 10), and is inserted into the head of the stapes. Its action is to lift the anterior part of the foot-plate of the stapes out of the oval window, thus antagonizing to a certain extent the action of the tensor tympani muscle. The stapedius obtains its nerve-supply by a filament of the facial nerve.

FIG. 10.



Inner Wall of Tympanic Cavity (Gray).

What arteries supply the tympanum?

The tympanic branch of the internal maxillary enters the Glaserian fissure, and is distributed to the membrana tympani. The tympanic branch of the internal carotid also supplies the membrana tympani. The stylo-mastoid extends from the posterior auricular to the back part of the tympanum and mastoid cells. The petrosal artery, a branch of the middle meningeal, enters the ear through the hiatus Fallopii, and a branch from the ascending pharyngeal passes up the Eustachian tube.

What nerves are distributed to the tympanum?

The tympanic branch of the glosso-pharyngeal (Jacobson's nerve) supplies the mucous membrane of the tympanum and fenestræ. The tympanic branch of the facial nerve supplies the stapedius muscle, and a branch from the otic ganglion supplies the tensor tympani muscle. The chorda tympani nerve passes across the tympanum between the handle of the malleus and the long process of the incus, without branches. It enters the tympanum by the iter chordæ posterius and emerges through the iter chordæ anterius.

Describe the tympanic plexus.

Jacobson's nerve (tympanic branch of the glosso-pharyngeal) divides into three branches, lying in grooves upon the promontory (Fig. 10). One joins the carotid plexus; a second, the greater superficial petrosal nerve; and a third, passing upward and forward, finally becomes the lesser superficial petrosal nerve.

Describe the Eustachian tube.

The Eustachian tube, which is about 1½ inches long, passes from the middle ear downward, forward, and inward to enter the pharynx. It affords communication between the air in the pharynx and that contained in the middle ear. The outer third consists of bone, commencing at the lower part of the anterior tympanic wall, and gradually narrowing to terminate at the angle of junction of the petrous and squamous portions of the temporal bones. The inner two-thirds of the Eustachian tube consist of elastic cartilage and fibrous tissue, which unite the inferior portion of a curved cartilaginous plate so as to form a tube. The mucous membrane lining the Eustachian tube is a continuation of that of the pharynx, and is covered with stratified ciliated epithelium.

Describe the muscles that dilate the Eustachian tube.

The muscles that dilate the Eustachian tube are—the levator palati muscle, which, arising from the petrous bone and cartilaginous portion of the tube, is inserted into the tissues of the soft palate; and the tensor palati, a flattened muscle which, arising from the sphenoid bone and the cartilaginous tube, passes as a broad tendon around the hamular process to form the broad aponeurosis of the soft palate. The action of both these muscles is to dilate the tube. Some of the fibres of the tensor tympani and tensor palati are blended, and an aponeurotic connection always exists along the Eustachian tube, so that probably these two muscles have no action entirely independent of each other. When the soft palate is drawn upward, the membrane is also retracted by the tensor tympani, and the Eustachian tube is at the same time dilated, so that, although a current of air enters the tympanum, it is prevented from forcing the membrane too far outward and interfering with the equilibrium of auditory tension. The tensor tympani and tensor palati receive nerve-filaments from the otic ganglion, but the levator palati is supplied by a branch from Meckel's ganglion.

What arteries and nerves are distributed to the Eustachian tube?

The Eustachian tube receives its arterial supply by the following arteries: the ascending pharyngeal, branches from the middle meningeal and internal maxillary, and a branch from the stylo-mastoid artery. Its nerves are, in addition to those supplying muscles of the tube, derived from the fifth and seventh pair and the glosso-pharyngeal.

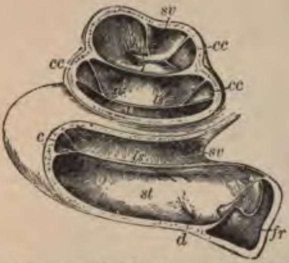
Describe the mastoid process of the temporal bone.

At birth the mastoid process consists of a small flattened tuberosity containing but one cell, and that of considerable size—the mastoid antrum. At puberty the mastoid process has become a distinct prominence, conical in shape, with its apex downward. The substance of the mastoid process consists of small cavities varying greatly, in number, size, and shape in different individuals. Some of them communicate with each other, and are lined with a continuation of the mucous membrane of the tympanum; which is here covered by squamous epithelium.

Describe the osseous boundaries of the internal ear, or labyrinth.

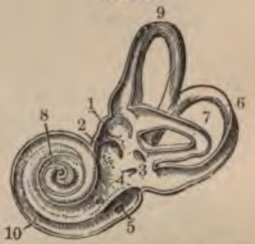
At all points the various channels and cavities of the labyrinth are deeply imbedded in the petrous portion of the temporal bone.

FIG. 11.



The Bony and Membranous Cochlea laid open: *st*, scala tympani; *sv*, scala vestibuli; *cc*, scala media or ductus cochlearis; *ls*, lamina spiralis ossea; *h*, helicotrema, or opening connecting the scalæ tympani and vestibuli.

FIG. 12.



The Bony Labyrinth laid open: 1, recessus ellipticus for utricle; 2, recessus sphæricus for saccule; 3, recessus cochlea; 4, pyramis vestibuli; 5, round window; 6, posterior semicircular canal; 7, external semicircular canal; 8, cupola of the cochlea; 9, superior semicircular canal; 10, lamina spiralis ossea projecting from the modiolus into the calibre of the canal of the cochlea, and terminating in the cupola as a hook-like process called the "hamulus."

The bony labyrinth consists of a central cavity, called the "vestibule," from the walls of which spring, like arches, the semicircular canals, while through the anterior wall of the vestibule a canal leads into the snail-shaped cavity of the cochlea (Figs. 11, 12).

Describe the contents of the osseous labyrinth.

The vestibule contains fluid and two distinct membranous sacs, the utricle and saccule (Figs. 13, 14). The saccule communicates with one of the membranous tubes of the cochlea, the ductus cochlearis, by means of a slender membranous tube, the canalis reuniens, while the cavity of the utricle is continuous with that of the membranous semicircular canals, so that the membranous labyrinth may be said to consist of a system of cavities with membranous walls containing a fluid, the endolymph, and nearly surrounded by another fluid, the perilymph (Fig. 14).

FIG. 13.

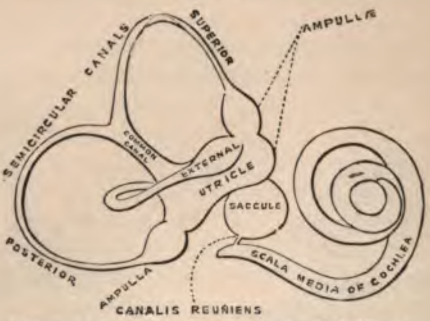


Diagram of the Membranous Labyrinth (Gray).

FIG. 14.

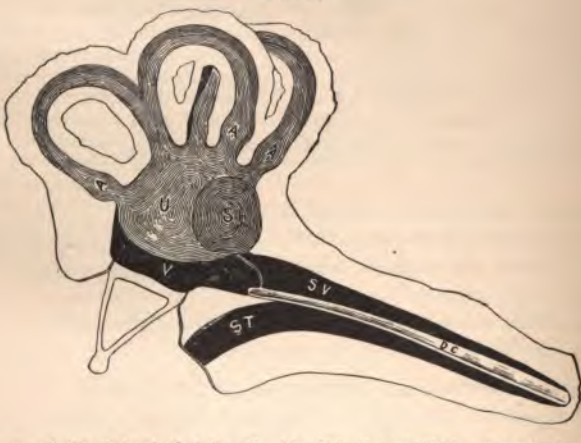
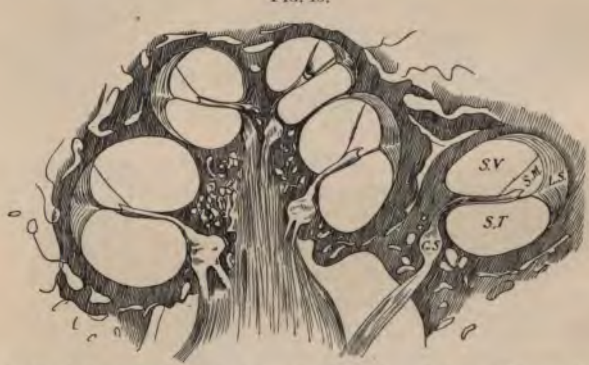


Diagram of the Labyrinth (after Buck): *V* is the vestibule, or central cavity, which is nearly filled by the utricle (*U*) and the saccule (*S*). Near the foot-plate of the stirrup there is free fluid, which also extends up into the scala vestibuli (*SV*) of the cochlea. The ductus cochlearis (*DC*) communicates by a slender membranous channel (canalis reuniens) with the saccule. Between the cochlear duct and the scala tympani (*ST*) is a narrow white band representing the membrana basilaris. At the extreme tympanic end of the scala tympani a faint white line indicates the position of the membrana tympani secundaria. The ampullæ (*A*, *A*) of the membranous semicircular canals in these regions fit pretty closely their surrounding bony walls.

A diaphragm, consisting partly of bone (lamina spiralis ossea) and partly of membrane (membrana basilaris), divides the cavity of the cochlea into an upper and lower space of nearly equal size (Fig. 15). The upper, the scala vestibuli, communicates with the cavity of the vestibule, and the lower, the scala tympani, ends abruptly at the round window (Fig. 14). The upper space (scala vestibuli) is divided by a diaphragm (Reissner's membrane) placed at an angle of 45° with the membrana basilaris, into the scala vestibuli proper and the scala media, or ductus cochlearis (Fig. 15), which, as already described (Fig. 13), communicates with the saccule by means of the canalis reuniens. The scala media, or ductus cochlearis, contains endolymph and the organ of Corti (Fig. 18).

FIG. 15.

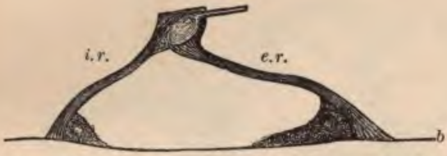


Longitudinal Section of the Cochlea, showing the relations of the scalæ, the ganglion spirale, etc. (Gray): *S.V*, scala vestibuli; *S.T*, scala tympani; *S.M*, scala media; *L.S*, ligamentum spirale; *G.S*, ganglion spirale.

Describe the organ of Corti.

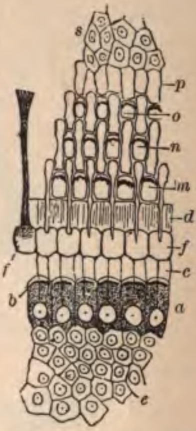
The organ of Corti rests upon the membrana basilaris about midway between the lamina spiralis ossea and the outer wall of the ductus cochlearis. It extends from the vestibule to the cupola of the cochlea, and to it are distributed nerve-fibres from the cochlear branch of the auditory nerve. Corti's organ is made up of a nearly central arch, formed by the inner and outer rods or pillars of Corti (Fig. 16), the bases of which are farther apart as the organ of Corti ascends from the vestibule to the cupola. There are at the outside of the arch four rows of ciliated cells, and at the inner side one row, which receive terminal filaments from the cochlear branch of the auditory nerve. The name "hearing cells" is sometimes applied to these hair-cells. There is a peculiar fenestrated membrane, the lamina reticularis, into whose netlike structure project the cilia of the outer hearing cells, which are covered and protected by a gluelike substance, the membrana tectoria (Figs. 17, 18). The rods of Corti have been estimated at about 10,500, while the number of hair-cells is estimated to be about 21,300.

FIG. 16.



Pillars of Corti: *i. r.*, inner pillar; *e. r.*, outer pillar.

FIG. 17.



Corti's Organ of the Cochlea, seen from above, × 300: *c*, row of inner pillars; *f*, row of outer pillars, of which one is shown in its entirety at *b*; *a*, row of inner hair-cells or hearing cells; *e*, inner supporting cells; *d*, first row of elements of lamina reticularis, through the openings of which the outer hair-cells protrude; *m*, *n*, *o*, successive rows of outer hair-cells or hearing cells: *s*, outer supporting cells (Kölliker).

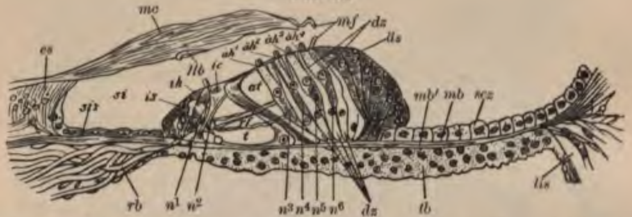
Describe the contents of the semicircular canals.

The membranous semicircular canals occupy scarcely a third of the space inside the bony canals, except at the ampullæ, where they hug the bony walls more closely. The space between the membranous canals and the bony wall is occupied by connective tissue rich in blood-vessels rather than with free fluid, as in the cochlea (Fig. 19).

What are the otoliths?

The otoliths are granular, amorphous, sometimes crystalline, particles found along the walls of the utricle, saccule, ampullæ, membranous canals, on the periosteum of the osseous semicircular canals, and in the fluid of the cochlea. They consist of about 75 per cent. mineral matter, mostly carbonate of lime, and organic material resembling mucus in its physical and chemical characteristics. The function of the otoliths has not been determined, but it has been suggested that they exert a damping action upon the vibrations of the terminal fibres of the hair-cells. In some of the lower animals they are huge in size compared with those of man, and assume fantastic shapes.

FIG. 18.

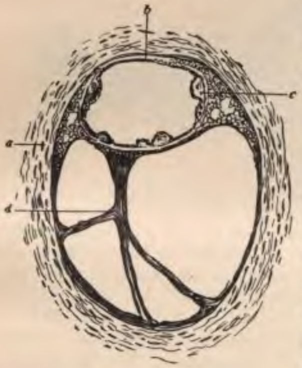


Transverse Vertical Section of Corti's Organ of a man twenty-nine years old (Gruber, after Retzius): *es*, limbus laminæ spiralis; *mc*, membrana tectoria; *Hb*, Hensen's striæ; *mf*, fibres of attachment of the membrana tectoria to the zona tecta; *si*, sulcus spiralis; *siz*, epithelium of the sulcus spiralis; *is*, inner supporting cells; *ic*, inner rod cells in connection with the outer rod cells, between which is seen the tunnel (*t*) of Corti; *ih*, inner hair-cell; *äh*^{1}–*äh*^{4}, outer hair-cells; *dz*, Deiters' cells; *äs*, Hensen's supporting cells; *rb*, nerve-fibres of the ramulus basilaris; *n*^{1}–*n*^{6}, outer bundles of the spiral nerve-fibres; *rf*, radiating tunnel fibres; *at*, inner part of Nuel's space; *mb*, upper layer of the membrana basilaris; *mb′*, lower layer of the membrana basilaris; *tb*, layer covering the tympanic surface of the membrana basilaris; *lis*, ligamentum spirale.

What is the origin of the auditory nerve? and to what portions of the labyrinth is it distributed?

The auditory nerve originates by three fasciculæ from the superior vermiformis process of the cerebellum and from the inner and outer nuclei, formed chiefly by the gray substance of the posterior pyramid and restiform body. The nerve emerges, superficially, from a groove between the olivary and restiform bodies at the lower border of the pons. At the bottom of the internal auditory canal it divides into the cochlear and vestibular divisions, both of which contain ganglion cells. The cochlear nerve divides into numerous filaments to enter the modiolus, and sends branches to each of the hair-cells (Figs. 18, 20). The vestibular nerve divides into three branches: the filaments from the upper branch enter the vestibule through the macula cribrosa at the bottom of the internal meatus, and are distributed to the utricle and the ampulla of the external and superior semicircular canals; the middle branch is distributed to the saccule, and the inferior branch passes to the ampulla of the posterior semicircular canals (Fig. 20).

FIG. 19.



Section through the Osseous and Membranous Semicircular Canals (Politzer): *a*, osseous semicircular canal; *b*, place of attachment of the membranous semicircular canal; *c*, elevations on the inner surface of the membranous semicircular canal; *d*, vascular bands of connective tissue.

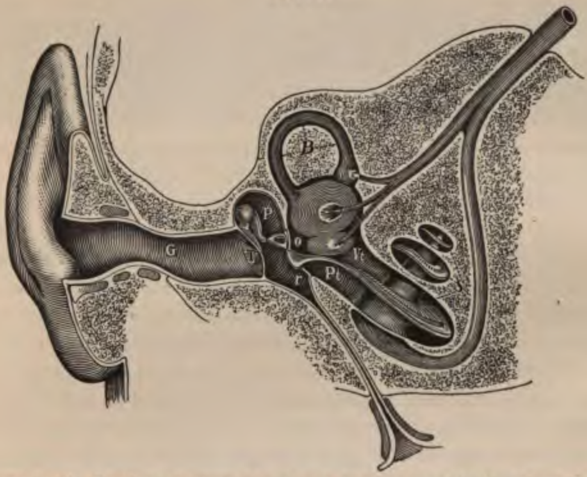
What is the function of the semicircular canals?

They appear to be a peripheral space-organ, and, furthermore, act through centres in the brain to regulate the movements of the muscles of the eye, and probably all the muscles of the body, for the preservation of equilibrium. The power of maintaining equilibrium is derived from the education of touch and sight and information derived from the peripheral space-organ within the ear, which informs the brain of the position of the head, and regulates the movements of the muscles for the preservation of equilibrium. If pressure be made upon the membrane of the round window, dizziness and an inclination to fall backward are produced as the result of the pressure transmitted to the ampulla of the posterior canal. If the foot-plate of the stapes be pressed upon, a rocking sensation of the head from side to side will be felt, indicative of the transference of the pressure to the ampulla of the superior canal. It is impossible to transmit pressure to the fluid of the horizontal canal, and when strong pressure is made upon the fluid within the vestibule, there is produced dizziness, without sensation of falling in any especial direction.

What are the functions of the vestibule and cochlea?

Except that in a general way the vestibule and cochlea have to do with the sense of hearing, the functions of these parts of the ear are not clearly understood. It is supposed that the individual hair-cells and rods of Corti vibrate to single tones, and that a compound sound causes the vibration of a number of hair-cells proportionate to its composite character.

FIG. 20.



Diagrammatic Section through the Right Ear (Czermak): G, external auditory meatus; T, tympanic membrane; P, tympanic cavity; O, oval foramen; r, round foramen; B, semicircular canal; S, cochlea; Vt, scala vestibuli; Pt, scala tympani.

TESTS FOR HEARING.

What is hearing?

Hearing is the faculty of the perception of sound.

What is sound?

Sound is a peculiar sensation excited in the organs of hearing by the vibratory motion of bodies, the effects of which are transmitted to the ear through an elastic medium.

Can sound exist without the presence of an organized being to perceive it?

No. Sound is a sensation, and should carefully be distinguished from the vibrations that produce it; which vibrations, of course, may exist without the presence of an organized being to perceive them.

What is the source of sound?

Sound is produced by the rapid vibrations that take place in the molecules of bodies when they are disturbed by shock or by friction. When a resonant body is struck, its molecules alternately approach and recede from one another with a velocity and amplitude of vibrations corresponding to the form, size, and molecular composition of the body; and this motion is transmitted by contact to any surrounding elastic medium, such as air. Sound-waves so produced are in part reflected in passing from a rarer to a denser medium, as, for example, when passing from air into water. If, however, a tense membrane, free to vibrate, is interposed between the air and any fluid or solid medium, the aërial vibrations are not reflected, but are transmitted into the more solid medium with little loss of their intensity. But for the membranes of the middle ear sound-waves transmitted from the ear to the lymph of the labyrinth would lose intensity to such a degree as to be inaudible.

What is acoustics?

Acoustics is that department of physics which treats of sounds. A rudimentary knowledge of the laws of acoustics is essential to an understanding of the physiology of the ear.

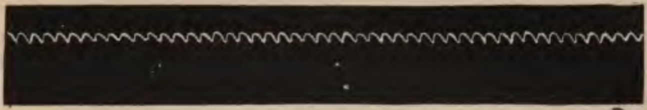
What is the science of music?

The science of music treats of a peculiar class of sounds and combination of sounds calculated to produce pleasurable emotions. Such sounds are distinguished from noises, which are sounds either of very short duration, like the reports of firearms, or are a mixture of many discordant sounds.

What is pendulum vibration?

If a needle be attached to one arm of a vibrating tuning-fork, and if in contact with the end of the needle a piece of smoked paper be moved at a uniform velocity, a tracing of the vibrations of the needle will be scratched upon the paper (Fig. 21). This tracing is a record of the *number* of vibrations of the fork during a given time, and of the *amplitude* of the vibrations. The record is regular and uniform, and so similar to that produced by a pendulum under similar circumstances that Huxley has described this form of vibration under the name of "pendulum vibration."

FIG. 21.



Tracing on Smoked Paper produced by the Vibrations of a Tuning-fork.

What is a tone?

A tone is a sound produced by a simple pendulum vibration. It has the characteristics of quality or "timbre;" intensity, volume or loudness; and pitch (high or low tone).

What is meant by the quality or "timbre" of a tone?

The quality of a tone depends largely upon the *material* of the substance which produces the tone. The quality of the note emitted by striking a strip of wood is entirely different as regards its quality or "timbre" from that produced by striking a rod of metal. A note produced from an organ, a violin, and a cornet may in each case have the same pitch and volume, but will differ widely from one another as regards quality or timbre.

Upon what does the intensity of a tone depend?

The intensity of a tone depends upon the force and amplitude of the vibrations which produce it. When a tuning-fork is first made to vibrate, its tone is comparatively intense or loud, because the force and amplitude of its vibration are comparatively great, but as it continues to vibrate its tone is heard less and less distinctly, because the force and amplitude of its vibrations are becoming less and less. The pitch of the tone, however, remains the same until the fork ceases to vibrate.

Upon what does the pitch of a tone depend?

The pitch of a tone depends upon the rapidity of the vibrations that produce it. The more rapid the vibrations, the higher the pitch. The human ear is generally able to distinguish the tone produced by a tuning-fork vibrating only sixteen times during a second, and also that of a fork vibrating thirty-eight thousand times a second. The capacity, however, to distinguish sounds of very low or very high pitch varies greatly in individuals, but the ears of most persons are more sensitive to sounds of low than to those of high pitch. Prof. Tyndall says: "The squawk of the bat, the sound of the cricket, even the chirp of the common house-sparrow, are unheard by some persons who for lower sounds possess a sensitive ear."

The inability to hear high notes increases with age, and generally also as the result of disease of the labyrinth or acoustic nerve; and in testing the acuteness of hearing by means of tuning-forks and Galton's whistle it is well to bear this fact in mind. For careful tests as to the sensitiveness of the perceptive apparatus it is well for the aurist to be provided with at least five forks, the lowest (C_{-2}) giving 32 vibrations during a second and the highest (c_4) yielding 2048 vibrations in a second. Galton's whistle and König's rods will be found useful also for making tests of this kind. König's rods are ten steel cylinders, 20 mm. in diameter, suspended by cords attached to them at a distance from each end of one-fifth of the length of each rod. The rods are of such a length that when struck with a hammer they produce tones, the lowest of which give 4096, and the highest of 32,768, vibrations per second.

Galton's whistle for testing the higher tones of the scale is more convenient than König's rods. It consists of a metal tube so perforated as to cause a whistle when air is blown through it by means of a rubber bulb attached to the proximal extremity of the instrument. The distal extremity is closed by a metal rod capable of being moved backward and forward within the tube by a micrometer screw. The length of the column of air within the tube beyond the perforation, and consequently the pitch of the note emitted by the whistle, are determined by the position of the rod within the tube. The micrometer screw is graduated to indicate single numbers, while on the side of the tube is a scale to show tens; so that by turning the micrometer screw the metal rod within the hollow cylinder can be placed in any position indicated by a number on a scale having a range of from one to one hundred and twenty. The following table indicates the number of vibrations per second of the note emitted by the whistle corresponding with the numbers on its scale:

Vibration pr. Sec.	84000	56000	42000	33600	28000	24000	21000	18666
Scale	10	15	20	25	30	35	40	45

Vibration pr. Sec.	16800	15273	14000	12923	12000	11200	10500	982
Scale	50	55	60	65	70	75	80	85

Vibration pr. Sec.	933	8842	8400	8000	7591	7305	7000
Scale	90	95	100	105	110	115	120

What is the number of vibrations per second producing the highest and lowest notes used in music?

Helmholtz states that the human ear is able to distinguish, as musical notes, tones lying between 16 and 38,000 vibrations per second, or a range of about eleven octaves, but that the lowest note used in orchestral music is E^{-2} or one of 40 vibrations per second. In pianos the lowest note in general use is C_{-2}, 32 vibrations per second; and the highest, seven octaves above it is c_5, of 4096 vibrations during a second. The following table is from Appun:

$C^{-2}=32$	$D^{-2}=36$	$E^{-2}=40$	$F^{-2}=42,_{66}$	$G^{-2}=48$	$A^{-2}=53,_{33}$	$H^{-2}=60$
$C^{-1}=64$	$D^{-1}=72$	$E^{-1}=80$	$F^{-1}=85,_{33}$	$G^{-1}=96$	$A^{-1}=106,_{66}$	$H^{-1}=120$
$c=128$	$d=144$	$e=160$	$f=170,_{66}$	$g=192$	$a=213,_{33}$	$h=240$
$c^1=256$	$d^1=288$	$e^1=320$	$f^1=341,_{32}$	$g^1=384$	$a^1=420,_{66}$	$h^1=480$
$c^2=512$	$d^2=576$	$e^2=640$	$f^2=682,_{64}$	$g^2=768$	$a^2=853,_{32}$	$h^2=960$
$c^3=1024$	$d^3=1152$	$e^3=1280$	$f^3=1365,_{28}$	$g^3=1536$	$a^3=1706,_{64}$	$h^3=1920$
$c^4=2048$	$d^4=2304$	$e^4=2560$	$f^4=2710,_{56}$	$g^4=3072$	$a^4=3413,_{28}$	$h^4=3840$
$c^5=4096$	$d^5=4608$	$e^5=5120$	$f^5=5421,_{12}$	$g^5=6144$	$a^5=6826,_{56}$	$h^5=7680$
$c^6=8192$	$d^6=9216$	$e^6=10240$	$f^6=10842,_{24}$	$g^6=12288$	$a^6=13653,_{12}$	$h^6=15360$
$c^7=16384$	$d^7=18432$	$e^7=20480$	$f^7=21684,_{48}$	$g^7=24576$	$a^7=27306,_{24}$	$h^7=30720$

What is harmony?

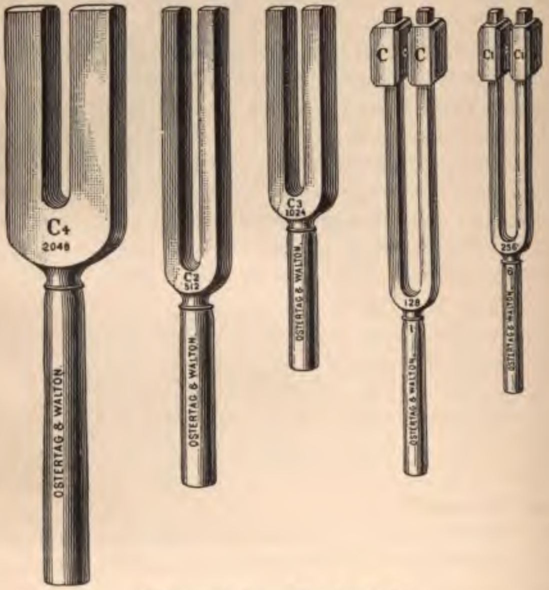
If the rates of vibration in a second of two notes simultaneously produced stand to each other in the ratio of simple multiples, so that while the low note makes one vibration the high note makes two, three, four, etc., the notes are said to be in harmony or concord, and the result is consonance. These are the ratios of the human voice in ordinary speaking or singing, and, according to Wolf, speech has a compass of five octaves, from c to c_5. The simplest ratio is $\frac{2}{1}$, and to this the name *octave* is given. In this case the higher note has double the number of vibrations of the lower. The ratio of the notes in the diatonic major scale is as follows:

C.	D.	E.	F.	G.	A.	B.	C.
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	$\frac{1}{2}$

What kind of a tuning-fork is used in testing the hearing?

The tuning-fork used to test the hearing should be large enough to secure sufficient intensity or loudness of tone. It is not absolutely necessary, but desirable, to have the tuning-fork provided with movable clamps, so as to deaden over-tones (Fig. 24). While it is more convenient, as stated, for the aurist to be provided with at least five forks of different pitch, yet one sounding the note c_2 (512 vibrations per second) will generally answer the purposes of ordinary clinical investigations. It is convenient to have at hand a small tuning-fork emitting a tone of feeble intensity (Fig. 23), in order to confine the sound to one ear; because when a very heavy tuning-fork is employed in examining patients whose hearing is greatly impaired only in one ear, it is impossible to be certain that the sound of a large

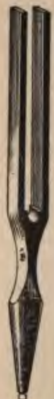
FIG. 22.



Hartman's Set of Tuning-forks.

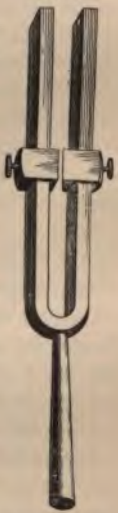
fork is not heard by the ear in which the hearing is better. When the fork is used for testing the hearing of the ear in which the hearing is more deficient, a large fork, provided with movable clamps, can, however, generally be made to answer the same purpose by placing the clamps sufficiently low down upon the tines of the instrument, the tone emitted by the fork being less and less intense the nearer the clamps are placed to the handle of the fork. Two of the forks shown in Figure 19 are provided with movable spring-clamps, and each of their tines is graduated by grooves cut across it, into which the springs of the clamps catch as they are moved upon the tines. Each of the notches is marked by a letter representing the tone emitted by the fork when vibrating with the spring of the clamp in that notch.

FIG. 23.



Small Tuning-fork.

FIG. 24.



Lucae's Tuning-fork with Movable Clamps.

What is Weber's method of testing the hearing-power with a tuning-fork?

E. H. Weber demonstrated that when a vibrating tuning-fork is placed against the teeth or on a point of the cranium the tone is heard better by a person with normal hearing if the ears are closed by the fingers. If only one ear is closed, the fork is heard best in that ear. Weber, Rinne, and Toynbee attributed this phenomenon to increased resonance; Mach, to the obstruction of the outlet of sound-waves through the auditory canal; Politzer, to both causes; and Lucae, to the labyrinthine variations associated with the confinement of sound-waves. Probably each of these factors should be given due weight as a cause of the phenomenon.

It should be borne in mind that any obstruction to the exit of sound-waves from the middle ear when a tuning-fork is vibrating with its handle in contact with the teeth or at a point upon the cranium midway between each ear, will cause the sound of the fork to be heard most distinctly in the obstructed ear. The cause of obstruction may be impacted cerumen in the external auditory meatus, occlusion of the Eustachian tube, mucus within the tympanum, or thickening of the membrana tympani as the result of catarrh of the middle ear. Hence, if a patient is deaf in only one ear from any of these causes, a vibrating tuning-fork, with its handle in contact with the teeth or on a point on the cranium midway between the ears, will be heard by him *better in the deaf ear.* If, however, the hardness of hearing is due to impairment of the labyrinth or of the auditory nerve, the note of the tuning-fork will be heard *less distinctly in the deaf ear.*

In practising Weber's method of examining the hearing, the observer should bear in mind that the answers of some patients will largely be determined by their imagination, and that they at first will say that they hear the sound of the fork most distinctly in that ear in which the hearing is better, simply because *they think they should do so.* The test should be repeated sufficiently often to convince the observer that his patient's answers are reliable. It will, in all instances, be judicious to request the patient, while the fork is still vibrating upon the cranium, to close first one ear and then the other with a finger, and only after this has been done to ask him in which ear he now hears the sound of the fork most distinctly.

What is Rinne's method of examining the hearing-power?

Rinne observed that when a vibrating tuning-fork, with its handle in contact with the tissues over the mastoid process, ceased to be heard, the sound of the fork reappeared if it was held in front of the ear. *Aërial conduction is superior to tissue-conduction in individuals with normal ears.* If the tuning-fork is heard best by aërial conduction, the fact may be noted as Rinne+; or Rinne– if the contrary is the case; or, to be more exact, the number of seconds that the tuning-fork is heard upon the mastoid and in front of the auditory meatus may be given in the form of a fraction, the numerator of which will be less than the denominator if Rinne's method yields a positive result, and the contrary will be the case if Rinne's method gives a negative result. Thus, if the note of a c_2 tuning-fork whose handle is in contact with the mastoid process is heard for twenty seconds, and for fifty seconds when its tines are held close to the external auditory meatus, the fact may be noted thus: Rinne + $\frac{20}{50}$. If, however, the fork is heard for thirty seconds when its handle is in contact with the tissues over the mastoid process, and only ten seconds when its prongs are held close to the meatus, the fact should be noted as Rinne — $\frac{30}{10}$ (R. — $\frac{30}{10}$). In the first instance any hardness of hearing is due to impairment of the nervous part of the ear; in the latter case it is due to the result of disease or to imperfection of the outer or middle ear, or both.

It is a well-known fact that any rigidity of the conducting apparatus so alters the relation of tissue to aërial conduction that the former finally exceeds the latter. This change begins with the low notes. If Rinne's method be employed on a patient in whom there is only a slight impairment of the patency of the Eustachian tubes, with congestions of the mucous membrane of the tympanum, the result will be negative with forks emitting a very low-pitched note and positive for that of a higher pitch. That is, the sound of the fork of low pitch will be heard louder and longer when its handle is firmly pressed upon the mastoid process than when the tines of the fork are held in front of the meatus. This, however, will not be the case if a fork emitting a high-pitched tone be employed. In conditions in which there is great rigidity of the transmitting apparatus of the ear, the receptive apparatus remaining healthy, Rinne's test will yield a negative result with forks of high as well as low pitch. Generally, under such circumstances tissue-conduction will be apparently increased. That is, a tuning-fork with its handle pressed upon the tissues over the mastoid will be heard louder and longer than normal. When, instead of this being the case, tissue-conduction as well as aërial conduction is decreased, impairment of the functions of the internal ear should be suspected, although it should be borne in mind, when testing the hearing of patients past middle life, that tissue-conduction of sound is always decreased as the result of senility, and sometimes as the result of other causes besides disease of the internal ear.

In any case, however, in which the acuteness of hearing is reduced to the perception of words spoken in a loud voice close to the ear, if tissue-conduction is greater than aërial conduction only for forks of low pitch (C_1–c) while those of high pitch (c_3 c_4) are heard very imperfectly, if at all, either by aërial or tissue-conduction, the receptive apparatus, as well as the middle ear, is impaired. In such cases, although the tension of the structures of the middle ear can doubtless be removed by operative procedures, the performing of such an operation will not result in a great improvement in the patient's hearing.

What is Gelle's test (pressions centripetes)?

If the air within the auditory canal be compressed by means of Siegle's speculum or by any suitable instrument, a normal ear will hear the sound of a tuning-fork vibrating on the cranial bones with diminished intensity. This phenomenon is due to increased labyrinthine pressure, because when the air within the auditory canal is condensed the chain of bonelets with the foot-plate of the stapes is pressed inward. If ankylosis of the stapes exists, or if there is great immobility of the membrane or ossicles, the tone of the tuning-fork will remain unchanged during the test, while if the labyrinth is diseased and the stapes is movable, the application of Gelle's test will produce dizziness.

What is Bing's method of differential diagnosis between middle-ear and labyrinthine affections?

If a tuning-fork is vibrated upon the mastoid process of a normal ear, after its sound is no longer audible it can be made to reappear if the meatus is tightly closed with the moistened finger. In cases of severe deafness, according to Bing, if this test yields a negative result, the hardness of hearing is due to a middle-ear affection, while if the result of the test is positive, the deafness is the consequence of a labyrinthine affection.

Dr. Bing uses also, as an aid to diagnosis, what he terms the "entotic" use of the speaking-trumpet, which consists in speaking into a speaking-tube connected by means of an air-tight joint with a catheter introduced into the mouth of the Eustachian tube. If the voice is heard better by this method than when the speaking-tube is used in the external meatus, there is hindrance to sound-conduction at the malleus or the incus, and the foot-plate of the stapes is freely movable in the oval window.

How is the hearing tested by means of a watch?

To test the hearing by means of a watch the patient should be seated with his eyes closed, or, better still, with his face so covered by a napkin or towel that it is impossible for him to see the watch, because many patients imagine that they hear a watch which they see held close to their ear. It is well also to request the patient to close firmly with his forefinger the ear that is not being tested. The aurist should hold the watch in his hand with its case open close to the patient's ear until the latter hears it distinctly, and then move his hand to a considerable distance and slowly bring the watch toward the ear being examined, observing the exact distance the watch is then *first* heard. The result of the examination may be expressed by a fraction, the numerator of which is the distance at which the patient hears the watch, and the denominator the distance at which the watch can be heard by a normal ear. For example: if the watch used in making the test is heard by a normal ear at 40 inches, and the patient hears it only at 15 inches, the fact may be recorded thus: Hearing for watch is $\frac{15}{40}$ (H. W. $=\frac{15}{40}$). If the watch is heard only on contact with the auricle, the record should read, Hearing for watch is $\frac{\text{contact}}{40}$; or if it is only heard by exerting considerable pressure with it upon the auricle, Hearing for watch is $\frac{\text{pressure}}{40}$.

The room in which the hearing is being tested by the watch should be as free from noise as possible, and the watch should invariably be made to approach the patient's ear from a distance as directed above, and the point be noted at which it is *first heard*, because, while the patient still hears the watch if it is slowly carried away from his ear, it will be found that he will continue to hear it at a much greater distance than that at which he would *first hear it* if it were made to approach his ear from a distance. The hearing may be tested in a similar manner by means of the acoumeter, an instrument devised by Politzer. The acoumeter gives the note c with about the same loudness as the sound of a loudly-ticking watch.

How is the voice employed as a means of testing the hearing-power?

In testing the hearing-power by the voice the patient should close the ear not being tested firmly with his forefinger, and either close his eyes or look in such a direction that it will be impossible to see the motion of the aurist's lips: the distance in feet should then be observed at which words are heard when spoken in a whisper, ordinary conversational tone, or a loud voice if the patient be very deaf. In making this test of the hearing-power it is best, in most instances, to employ single words of only one syllable. The result of the examination may be noted as a fraction, the numerator of which is the distance in feet at which the patient hears the words, and the denominator the distance in feet at which a normal ear can hear the same words. For example: if the patient hears whispered words 3 feet from his ear, and should hear them at 10 feet, the fact may be recorded thus: Whisper $\frac{3}{10}$.

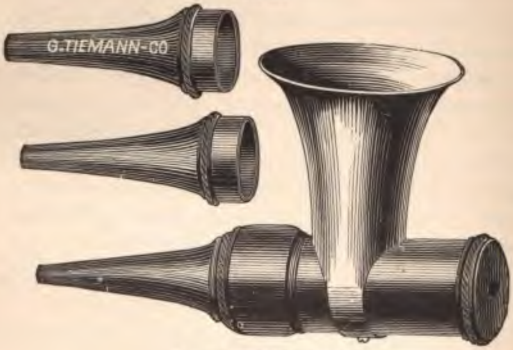
DIAGNOSIS AND TREATMENT OF DISEASES OF THE EAR.

Otoscopy.

What is otoscopy?

Otoscopy is the art of inspecting the visible parts of the ear. Ordinarily these parts are the auricle, the external auditory meatus, and the outer surface of the membrana tympani. Deeper portions of the ear are, however, visible when the overlying structures are destroyed by disease or are removed during an operation. Generally the dim outlines of the malleo-incudal joint can be seen through a normal or atrophied drum-head, and occasionally the chorda tympani nerve and other structures.

FIG. 25.

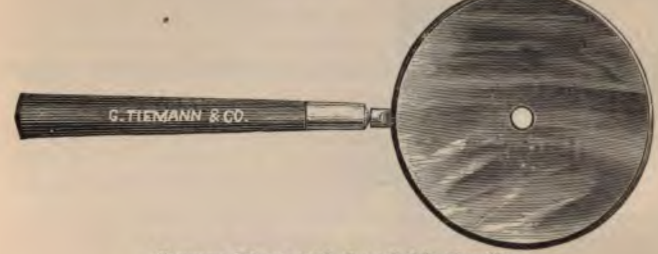


Brunton's Otoscope.

What is an otoscope?

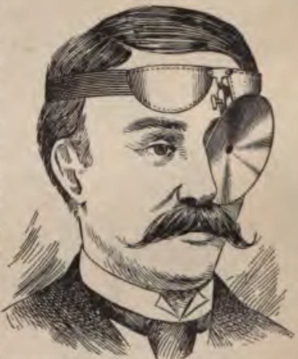
The name "otoscope" is often applied to an instrument consisting of a hollow cylinder to one end of which ear specula of various sizes may be adjusted (Fig. 25). The side of the cylinder is fenestrated for the admission of light, which, when the instrument is in use, falls upon a perforated mirror set at such an angle within the cylinder that the light is reflected from it through the speculum into the ear. The observer examines the condition of the parts by looking through the perforation in the mirror. An eye-piece containing a lens may be adjusted to the proximal end of the cylinder to enable the observer to obtain a magnified image of the membrana tympani. Although an excellent view of the membrana tympani can be obtained by means of this instrument, it has fallen into comparative disuse, modern otoscopy being generally accomplished by means of a reflector and an ear speculum.

FIG. 26.


G. TIEMANN & CO.

Concave Mirror with Detachable Handle.

FIG. 27.

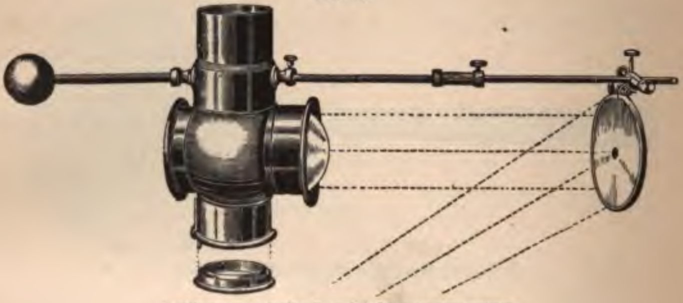


Sardy Head-band with Reflector.

Describe the reflector usually employed for otoscopy.

The reflector generally used to illuminate the auditory canal and its fundus is the same as that employed in laryngoscopy and rhinoscopy. It consists of a concave mirror about 3½ inches in diameter and of from 8 to 12 inches focus (Fig. 26), worn upon the forehead (Fig. 27) or attached to a light-concentrator (Fig. 28). The latter arrangement answers a better purpose for rhinoscopy and laryngoscopy than for otoscopy.

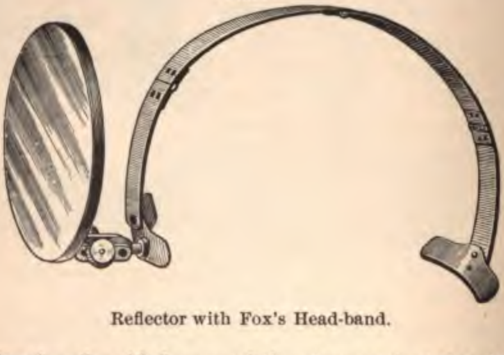
FIG. 28.



Reflector attached to Light-concentrator.

When the reflector is used to illuminate the interior of the auditory canal, a better view of its fundus is obtained by looking through the perforation than if the eye of the observer is at the side of the instrument. The nearer the eye of the observer approaches the perforation in the centre of the reflector, the more clearly will he be

FIG. 29.



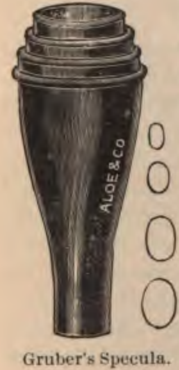
Reflector with Fox's Head-band.

enabled to see the minute details of the drum-head. For this reason a better view of the membrana tympani can often be obtained by means of a reflector held in the hand than by one worn upon the forehead. If, however, the reflector is attached to a head-band by means of two ball-and-socket joints, as in Figure 27, the eye of the observer can be brought much closer to the perforation in the centre of the reflector than if the reflector were attached to the head-band in the usual manner. The instrument known as Fox's head-band has a double ball-and-socket joint, by which a reflector may be attached to it, and, being constructed of metal, it will outwear those made of silk webbing or of similar material. It consists of four steel strips so hinged together that they can be folded about the mirror, thus occupying but little space. When opened the instrument assumes the shape of a line passing over the head (Fig. 29).

Describe the specula or ear-funnels used for otoscopy.

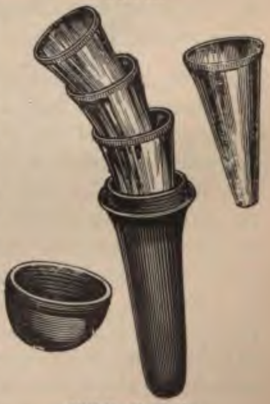
The specula used in otoscopy are funnel-shaped instruments constructed of hard rubber or metal. Different forms of these instruments are sold under the names of Wild's, Gruber's, Toynbee's, Turnbull's, Kramer's, and Politzer's specula. Gruber's specula (Fig. 30) are probably the best for ordinary purposes of otoscopy, because a transverse section of their calibre at right angles to their long axes more nearly corresponds with a similar section of the external auditory meatus. Wild's specula (Fig. 31) are, however, better adapted for use during an operation upon the middle ear. Ear specula are usually sold in "nests" (Fig. 31) of three or four sizes fitting into a case. Those

FIG. 30.



Gruber's Specula.

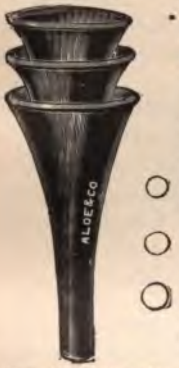
FIG. 31.



Wild's Specula.

specula constructed of hard rubber are easily broken, and those manufactured of German silver and nickel-plated are necessarily thicker than is desirable; a thin, solid-silver speculum, aside from its expensiveness, being the preferable instrument.

FIG. 32.



Toynbee's Specula.

What sources of light are used in otoscopy?

The sources of light used in otoscopy are natural and artificial. Sunlight, directed into the auditory canal either by the aid of an ear-speculum or by straightening the auditory canal by drawing the auricle upward, backward, and somewhat outward, was used almost exclusively in the methods of examination employed fifty years ago. Daylight, preferably that reflected from a white cloud, or artificial light, furnished by an argand burner fed by oil or gas, or the electric light, is now generally used for otoscopy. Whatever the source of the illumination, the light is directed into the auditory canal by means of the reflector. Sunlight is too intense for this purpose, and when brought to a focus by the reflector is so hot that, when directed into the auditory canal, there is danger of its burning the ear.

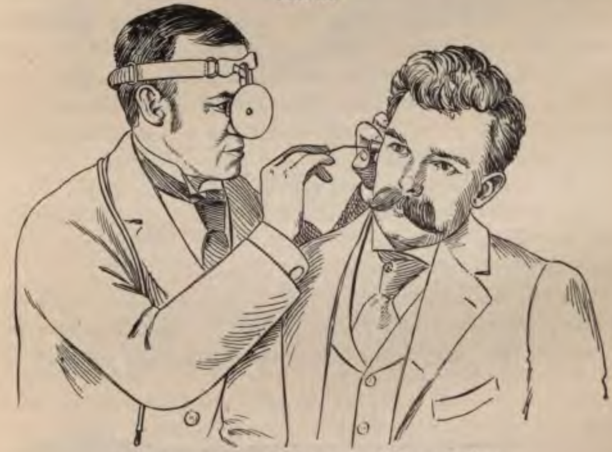
Describe the relative positions of patient and observer in otoscopy conducted with the reflector and speculum.

The patient and observer may both stand in front of a window or the source of artificial light, or both may be seated upon piano-stools so adjusted that the eye of the observer and the ear of the patient are in the same horizontal plane. The ear to be examined should be directed toward the observer, and the patient's face turned somewhat away from him, because the auditory canal generally extends in a direction inward, forward, and somewhat downward. If the reflector is held in the hand or worn upon the forehead, the source of light should be above or to one side of the patient's head, and so placed as to throw the auricle into the shadow. The light concentrator and reflector shown in Figure 28 may be used for otoscopy, the reflector so adjusted between the observer and patient that it will illuminate the fundus of the auditory canal.

How should the speculum be introduced into the auditory canal?

To introduce the speculum the observer should first direct the light from the reflector upon the orifice of the meatus, and then straighten the auditory canal by gently drawing the auricle upward, backward, and slightly outward, at the same time endeavoring to see the drum-head without the use of a speculum. In many instances this can be accomplished satisfactorily, and under such circumstances the observer should not be in haste to introduce the speculum, as it may dislodge and push into the field of view a flake of wax or epithelium, which will greatly interfere with a distinct view of the membrana tympani. The auditory canal having been straightened in the manner described and the parts being fully illuminated, the speculum is held by its rim with the thumb and finger and gently introduced with a slight rotary motion into the auditory canal, in such a manner that its long axis exactly corresponds with that of the canal. The greatest care should be exercised in introducing the speculum not to use it as a lever in such a manner as to bring its sharp edge in contact with the wall of the canal and cause pain; obstruction to the

FIG. 33.



Otoscopy with the Reflector and Ear-speculum.

progress of the speculum being overcome by moving the whole instrument in a direction opposite to that in which the obstruction is felt until the membrana is brought into view, when the speculum may, if necessary, be retained in position by grasping it and the auricle in the manner shown in Figure 33.

What are the chief obstacles to otoscopy?

The chief obstacle to the beginner is caused by so misdirecting the long axis of the ear-speculum that it does not correspond with the long axis of the auditory canal, so that a portion of the auditory canal is brought into view or only a portion of the membrana is seen. Under such circumstances the end of the speculum within the ear should be moved about until a satisfactory view of the drum-head has been obtained. Generally it will be found that the cause of failure has been that the axis of the speculum has been directed too far backward and upward.

Another cause of difficulty is excessive sensibility of the auditory canal or swelling of its walls, the result of diffuse inflammation. Sometimes a satisfactory view of its deeper parts can be obtained under such circumstances by gentle and persistent effort, a small speculum being used to dilate the auditory canal. Should this not succeed, a small piece of tupelo-wood may be placed within a small rubber tube and introduced into the auditory canal. If now the proximal end of the cylinder of tupelo-wood be moistened from time to time with a drop of water, it will in most instances within a few moments almost painlessly dilate the canal sufficiently to permit a satisfactory view of the membrana tympani.

It should be borne in mind that it requires but a small object, such as a few hairs, a flake of epithelium, or a small mass of cerumen, to obscure the view of the membrane. Generally the end of the speculum can be passed beyond any hairs growing at the orifice of the external auditory meatus. Small flakes of epithelium or masses of cerumen may be removed by means of a small dossil of absorbent

FIG. 34.

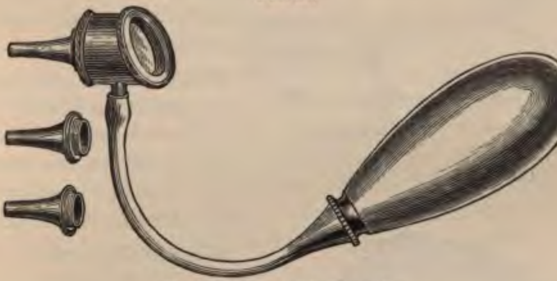
Harrison Allen's Steel Probe.

cotton at the end of an Allen probe (Fig. 34). If necessary the dossil of absorbent cotton may be dipped into a solution of peroxide of hydrogen to loosen any little mass of pus or cerumen closely adherent to the wall of the canal.

What is Siegle's pneumatic speculum?

Siegle's pneumatic speculum (Fig. 35) is an air-tight chamber to which specula of various sizes can be attached by means of a screw-joint. The side of the air-tight chamber carries a perforated knob, over which is slipped a rubber tube terminating in a rubber bulb. The proximal end of the instrument is glazed either with plane glass or with a convex lens set at an angle of forty-five degrees with the long axis of the instrument. When the instrument is in position within the auditory canal, the surgeon is enabled to judge of the mobility of the whole or of a part of the membrana tympani by observing its movements during condensation and rarefaction of the air in the auditory canal brought about by the action of the surgeon's hand upon the rubber bulb. Before using the instrument it is well to slip a short piece of wet rubber tubing over the end of the speculum, to ensure its fitting into the auditory canal as nearly air-tight as possible. When the Eustachian tube is impervious to air the pneumatic speculum furnishes the only means of determining the mobility of a part or the whole of the membrana tympani.

FIG. 35.



Siegle's Pneumatic Specula.

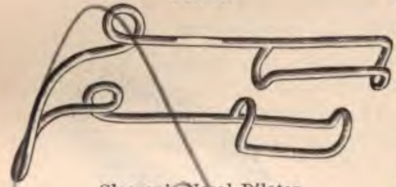
RHINOSCOPY.

Examination of the Eustachian Tubes and Middle Ear.

What is rhinoscopy?

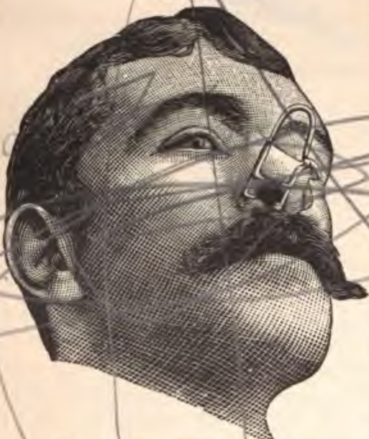
Rhinoscopy is the art of inspecting the nasal cavities, and may be divided into anterior and posterior rhinoscopy. Anterior rhinoscopy is the inspection of the anterior nares through the nostrils, and posterior rhinoscopy is the inspection of the vault of the pharynx and of the posterior nares from behind.

FIG. 36.



Gleason's Nasal Dilator.

FIG. 37.



Gleason's Nasal Dilator applied.

What are the anterior and posterior nares?

These terms should be applied solely to the anterior and posterior openings of the anterior nasal cavities.

What is the posterior nasal chamber or post-nasal space?

The post-nasal space, as it is at present more commonly called, is the cavity bounded in front by the posterior nares, above by the vault of the pharynx, behind by the pharyngeal wall, and below by the soft palate.

How is anterior rhinoscopy accomplished?

The simplest method is to raise the tip of the nose with a finger, and draw the ala away from the septum by means of a bent probe. If now the patient's head is tilted somewhat backward and a strong light is made to enter the dilated nostril, the nasal cavity will be illuminated for a considerable distance, and the condition of its lining mucous membrane may be inspected. The opening of the nostril may, however, be effected more conveniently by means of an instrument called a "nasal dilator," of which there are endless varieties for sale in the market. The instrument shown in Figure 36 is self-retaining when in position within the nose, and hence is not liable to cause embarrassment by falling from the nose during an operation and becoming temporarily lost. It should be inserted by compressing the spring of the instrument between the thumb and forefinger of the right hand, with the concavity of the instrument upward. The blades of the instrument should be placed within the vestibule of the nose parallel with its floor, and the dilator then so turned upward that the rim of the nostril falls into the space between the wires forming each blade of the dilator (Fig. 37). All nasal dilators, however, tend to expose the parts in a distorted condition, and thus deceive the observer as to the amount of breathing-space that exists in the anterior nares.

Large-sized ear-specula, by not dilating the nostril so widely, enable the observer to judge of the amount of obstruction to nasal respiration (produced by a deviated septum or anterior hypertrophy) much more accurately than can be done by any nasal dilator. When using either dilator or speculum a strong light should be reflected into the nose, and the instrument and patient's head should be so moved that the different parts of the interior of the nose are successively brought into view. Any secretions that obstruct the view should be wiped away with cotton wrapped on the end of an applicator, and any change in the bulk of the parts should be tested with the probe in order to determine its density. If an anterior hypertrophy obstructs the view of deeper structures, a 4 per cent. solution of cocaine should be applied to reduce its size and allow light to penetrate into the deeper parts of the interior of the nose.

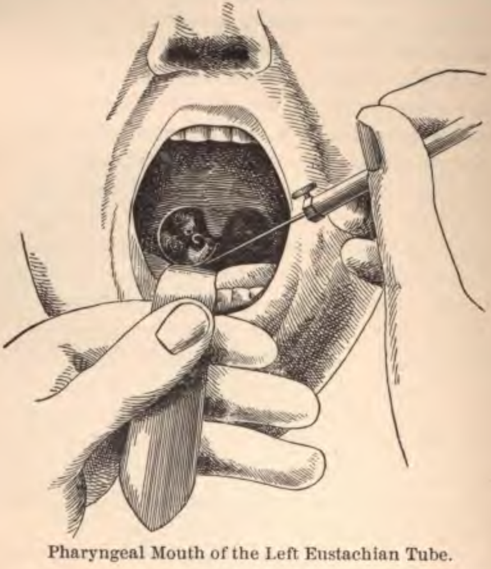
Describe the appearance of the interior of the nose as seen in anterior rhinoscopy.

The first structure brought into view is the vestibule, in which are seen a number of coarse hairs called *vibrissæ*, while a fold of skin or mucous membrane lies between the vestibule and the inferior meatus. To the inner side is the septum, and to the outer side is the inferior turbinated bone, forming the roof of the inferior meatus. Above the inferior turbinated bone is the middle meatus, roofed in above, except for the olfactory slit, by the middle turbinated bone. Through the olfactory slit in some individuals a portion of the superior turbinated bone may be seen.

How are the posterior nares examined?

The observer should sit opposite to the patient, so that his eye is on the level with, and about a foot from, the mouth of the patient, whose head should be slightly raised and inclined backward. The knees of the observer should be either at the left or on either side of the patient's knees. For office use it is most convenient to have piano-stools, which can be raised or lowered, so that the difference in the heights of different patients can be compensated for, and the eye of the observer can be brought on a level with the eye of the patient, while the patient's head may rest upon a cushioned framework fastened to the wall. If a head-reflector be used, it is advisable to obtain an easy position for the head, and *then* move the reflector

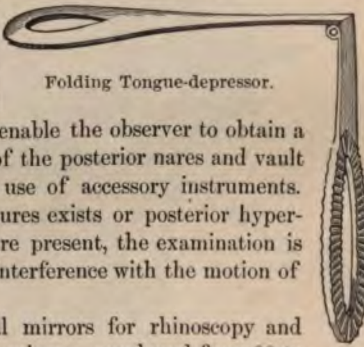
FIG. 38.



Pharyngeal Mouth of the Left Eustachian Tube.

until the disk of reflected light falls into the opened mouth of the patient with its centre at the base of the uvula, thus illuminating all the surrounding parts. The patient having opened his mouth and the tongue being held down by means of a tongue-depressor (Fig. 39), the rhinoscopic mirror (Fig. 41), having been warmed, should be introduced into the pharyngeal cavity behind the velum palati, and so placed as to reflect the light upward and forward into the vault of the pharynx and into the posterior nares (Fig. 44). For this purpose a No. 1 mirror is generally most useful, but larger or smaller mirrors can sometimes be used to advantage. Posterior rhinoscopy is much more difficult than laryngoscopy; but, except in the case of young children, patience and dexterity will almost always enable the observer to obtain a glimpse of the various parts of the posterior nares and vault of the pharynx without the use of accessory instruments. When disease of these structures exists or posterior hypertrophies or other neoplasms are present, the examination is usually easy because of their interference with the motion of the palate.

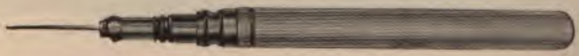
FIG. 39.



Folding Tongue-depressor.

A complete outfit of small mirrors for rhinoscopy and laryngoscopy consists of seven mirrors, numbered from 00 to 5 according to their size. The frame of each mirror is soldered to a stiff wire shank at an angle of 45°, and the shank of the mirrors may either be fixed into a permanent handle or the mirrors may be used with the universal handle (Fig. 42). Latterly the author has been using as a universal handle for mirrors, applicators, probes, small knives, and other instruments, the dissecting needle-holder (Fig. 40) employed by microscopists. This needle-holder is much more elegant in appearance than the universal handle, and is more

FIG. 40.



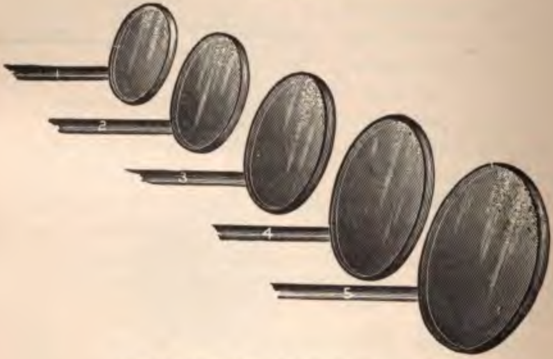
Dissecting Needle-holder, with binding screw.

convenient. It is made of white bone, and has at one extremity a nickeled screw-cap which is capable of immovably retaining any instrument that is inserted into the holder. Three sizes are kept in stock by most dealers in microscopes, and are retailed at an exceedingly small price compared with that of the universal handle.

What are the chief obstacles to posterior rhinoscopy?

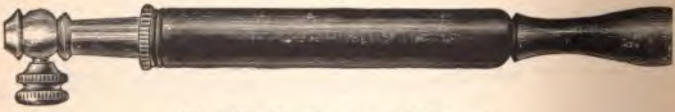
In many cases the palate will rise forcibly as soon as the mirror has been introduced, thus completely shutting off the view of the parts above. This difficulty can often be overcome by requesting the patient to breathe through his nose or emit a nasal sound like that of the French letter *n*. The observer should in all cases avoid touching the back of the tongue or pharyngeal wall, as otherwise gagging and retching immediately occur and further examination is rendered futile. Excessive irritability of the palate and pharyn-

FIG. 41.



Small Mirrors used in Laryngoscopy.

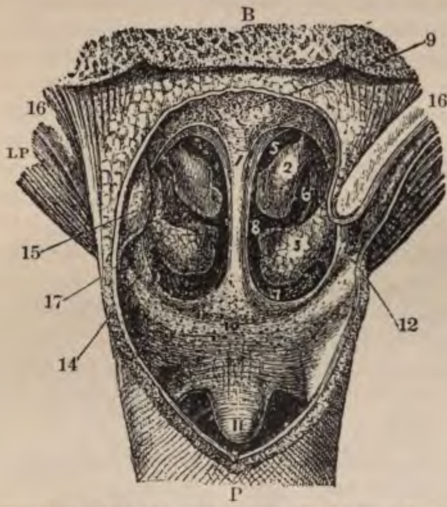
FIG. 42.



Adjustable Handle used with Mirrors.

geal wall can usually be relieved sufficiently to permit an examination being made with the rhinoscope by painting the parts with a 4 per cent. solution of cocaine. In operating it is often essential to be able to watch the movements of the instrument in the posterior nares. Under such circumstances the ends of a piece of small rubber tubing, such as is used for drainage in small wounds, may be passed, one through each nostril and out through the mouth. If, now, these ends are drawn tight and passed under that part of the tube which is outside the nose, they will be held in position, and a sufficient amount of elastic traction will be exerted upon the velum palati to

FIG. 43.



View of the Posterior Nares, the pharynx being laid open from behind (after Luschka): B, basilar process; P, pharynx; 1, septum; 2, middle turbinated bone; 3, inferior turbinated bone; 4, superior turbinated bone; 5, superior meatus; 6, middle meatus; 7, inferior meatus; 8, main passage of nostrils; 9, vault of the pharynx; 10, cushion of the soft palate; 11, posterior surface of uvula; 12, ridge formed by levator palati (L. P.); 13, salpingo-pharyngeal fold; 14, salpingo-palatine fold; 15, Eustachian prominence or cushion; 16, Eustachian tube, closed on the left and laid open on the right side; 17, Eustachian orifice.

draw it downward and forward away from the pharyngeal wall and maintain it in that position. There is at first some gagging and sneezing, which quickly subside, when the tubing may be maintained in position for some minutes without great pain or inconvenience to the patient.

Describe the appearance of the posterior rhinoscopic image.

Except in cases of cleft palate, it is impossible to obtain a complete posterior rhinoscopic image, such as is shown in Figure 43, but by varying the position of the mirror the different parts may be brought into view and studied one after the other. Usually the first object seen is a triangular plate, with its apex downward—the posterior margin of the nasal septum (1). Above it is a mass of glandular tissue called the "pharyngeal tonsil," while at each side, lower down, are the crater-like orifices of the Eustachian tubes (8). In front of these and projecting toward the septum are the posterior aspects of the turbinated bones. The middle turbinated bone is usually first brought into view, and rarely the dim outline of the superior turbinated bone may be distinguished above and in front of it. Below the middle turbinated bone the upper part of the inferior turbinated bone is readily perceived; but to see the lower part of this structure and the floor of the nose requires considerable practice in the use of the rhinoscopic mirror.

What pathological conditions of the nose and pharynx cause disease of the ear?

As the result of long-continued chronic naso-pharyngeal catarrh the Eustachian tubes and middle ear become affected in a large proportion of cases. In fact, disease of the nose and throat is by far the commonest cause of deafness. Especially if the catarrh be of the hypertrophic variety, so that nasal respiration is interfered with by the presence of anterior and posterior hypertrophies of the turbinate bodies, ecchondroses or exostoses from the septum, etc., is a disease of the Eustachian tubes prone to result. The same is true of a deflection of the septum sufficiently great to cause marked obstruction of one nostril. In many instances, doubtless, catarrh of the Eustachian tube and middle ear is the result of the extension by continuity of surface of a similar affection of the naso-pharynx. When one or both nasal chambers are obstructed, however, other causes probably bring about the same result. Posterior to the obstruction, in nearly all cases of nasal stenosis, a partial vacuum is formed during inspiration; as the result, the nasal mucous membrane is constantly engorged with blood in this locality. This condition may extend back far enough into the pharynx to involve the pharyngeal mouth of the Eustachian tube of one side. Probably most cases of one-sided deafness on the same side as an obstructed nostril may be explained in this manner. The hearing in such cases frequently improves rapidly after the removal of the nasal stenosis. But a posterior hypertrophy may be so situated as to interfere seriously with the normal circulation of blood in the mucous membrane covering the tube-mouth, and thus produce venous stasis in that locality. By far the commonest cause of Eustachian salpingitis, in children at least, is hypertrophy of the pharyngeal tonsil. When the adenoid overgrowth is so situated as to interfere with the return of blood from the mucous membrane of the Eustachian tubes, stenosis results because of engorgement and inflammation, and the hearing deteriorates more and more as the result of each succeeding attack of coryza. Under such circumstances, if the hypertrophy of

FIG. 44.

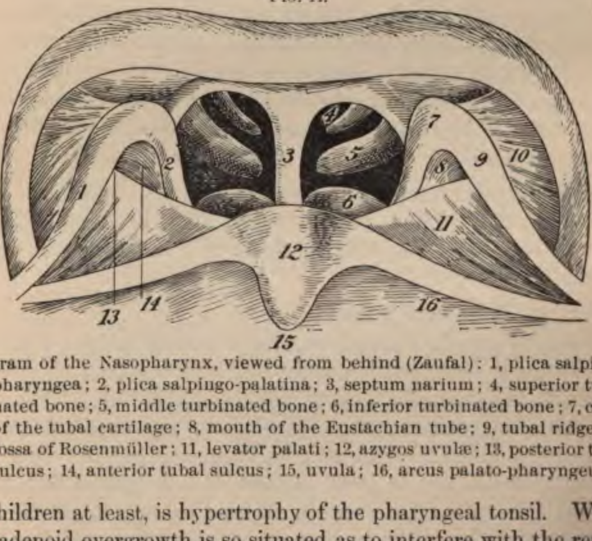


Diagram of the Nasopharynx, viewed from behind (Zaufal): 1, plica salpingo-pharyngea; 2, plica salpingo-palatina; 3, septum narium; 4, superior turbinated bone; 5, middle turbinated bone; 6, inferior turbinated bone; 7, curve of the tubal cartilage; 8, mouth of the Eustachian tube; 9, tubal ridge; 10, fossa of Rosenmüller; 11, levator palati; 12, azygos uvulæ; 13, posterior tubal sulcus; 14, anterior tubal sulcus; 15, uvula; 16, arcus palato-pharyngeus.

the pharyngeal tonsil has not existed too long, a complete restoration of the hearing may be expected to follow the removal of a portion of the hypertrophied gland. It must not be supposed, however, that by removing the nasal disease which produced the aural affection a complete restoration of the hearing will result in every instance. In most cases of this kind careful treatment of the tubal or middle-ear disease is *not only judicious, but absolutely necessary.*

Describe the appearance of the pharyngeal orifices of the Eustachian tubes as seen by means of the rhinoscopic mirror.

The pharyngeal mouths of the Eustachian tubes, bordered by their cartilaginous lips, appear as two crater-shaped elevations in front of Rosenmüller's fossa (Fig. 44). The mucous membrane at the entrance of the tube is, in the normal state, paler than that in its vicinity, which is of a deep-red color over the cartilaginous lips. In atrophy of the tube-mouths the mucous membrane covering the lips of the tube is pale in color and the parts appear shrunken. In catarrh of the Eustachian tube the mouth of the tube will sometimes appear dilated by a mass of mucus exuding from it, and under such circumstances the tube-mouth is generally greatly swollen.

What three methods are used to test the patency of the Eustachian tubes and introduce air into the middle ear?

Valsalva's and Politzer's methods and catheterization of the Eustachian tubes.

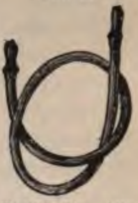
What is Valsalva's method?

Valsalva's method consists in a forced expiration, the mouth and nose being closed. In this method air is forced from the pharynx through the Eustachian tubes into the middle ear. If the aurist examines the membrana tympani while the patient inflates the middle ear by Valsalva's method, the drum-head will be observed to move outward, and in most instances it will become slightly congested. If an aural stethoscope be used to connect the ear of the patient with that of the aurist, a slight noise will be heard as the air enters the patient's middle ear.

Describe the aural stethoscope, or auscultation-tube?

This instrument consists of about 3 feet of thin rubber tubing into the ends of which appropriate ear-pieces are inserted. One ear-piece should be of white bone for the aurist's own ear, and the other end of hard rubber to be inserted into the auditory canals of his patient's ears. In using the aural stethoscope for the auscultation of the right ear of a patient the aurist should first insert the white end-piece into his own right ear, and pass the tube behind his neck, so that its weight may rest upon his shoulders, as there will be little danger of the ear-piece being drawn from his ear during the examination of the patient if it be used in this manner. The patient is then instructed to place the hard-rubber ear-piece loosely in his ear and hold it in position with his thumb and finger. The aural stethoscope, or auscultation-tube, is sometimes but improperly called the "otoscope" (Fig. 45).

FIG. 45.



Toynbee's Auscultation-tube.

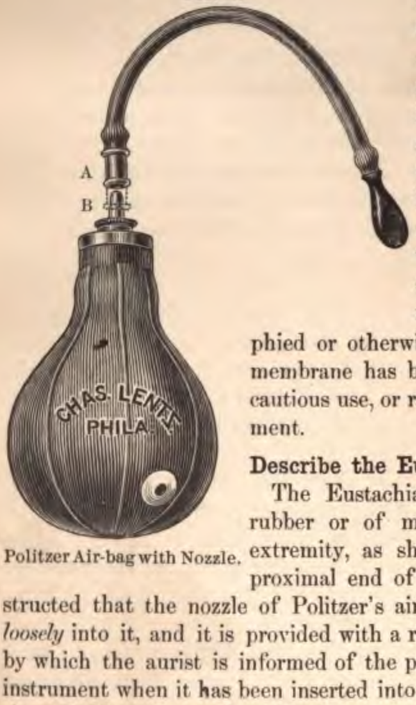
What is Politzer's method of inflating the middle ear?

In Politzer's method the patient is directed to hold a small quantity of water in his mouth until he is told to swallow. The aurist then takes the nose-piece of Politzer's air-bag (Fig. 46) between his middle finger and forefinger and inserts it into one of the patient's nostrils, and closes both nostrils firmly about the nose-piece by pressure with his thumb and finger. The patient is then told to swallow: as the patient's larynx is seen to rise at the commencement of the act of swallowing, the aurist quickly compresses the air-bag held in his right hand, thus forcing air through the nose and Eustachian tubes into the middle ear. If the auscultation-tube is used during this procedure, the air will be heard to enter the middle ear with the same audible *click* observed when Valsalva's method of inflating the middle ear is employed.

During the act of swallowing the soft palate rises, thus cutting off all communication between the posterior nasal chamber and the mouth, and at the same time the Eustachian tubes are rendered more patulous by the action of the tensor palati and other muscles, so that air forced into the nose by Politzer's method, having no other way of exit, readily finds its way into the middle ear through the tubes if their functions are not impaired as the result of disease. The same thing may be accomplished with greater convenience by requesting the patient to "puff out his cheeks" and compressing the air-bag while the mouth is thus inflated with air. Pronouncing certain syllables, like the words *hick*, *hack*, or *hock*, also causes an elevation of the soft palate and a dilatation of the Eustachian tubes, so that the middle ear can readily be inflated by means of Politzer's air-bag while the patient is pronouncing either of these words. The middle ears of young children are usually more easily inflated by means of Politzer's air-bag than those of adults, while in the case of infants air readily enters the middle ear if Politzer's air-bag be used while the child is crying.

No more force should ever be employed in compressing the rubber bag than is absolutely necessary to force air into the middle ear, and it is far better for the aurist to make several unsuccessful efforts to accomplish this purpose than to drive air from Politzer's air-bag into the middle ear with sufficient force to cause pain. While it is probably impossible to rupture a *normal* membrana tympani with Politzer's air-bag, yet several cases have been reported in which an atrophied or otherwise greatly diseased drum-membrane has been ruptured by the incautious use, or rather abuse, of this instrument.

FIG. 46.

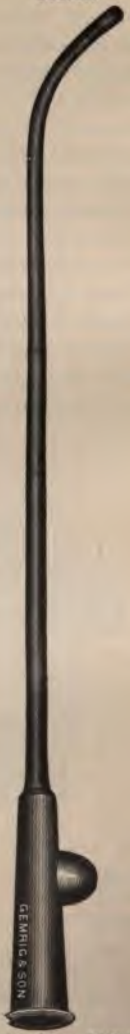


Politzer Air-bag with Nozzle.

Describe the Eustachian catheter.

The Eustachian catheter is a tube of rubber or of metal curved at its distal extremity, as shown in Figure 47. The proximal end of the instrument is so constructed that the nozzle of Politzer's air-bag (B, Fig. 46) will fit *loosely* into it, and it is provided with a ring or mark of some sort by which the aurist is informed of the position of the beak of the instrument when it has been inserted into the nose. At least three sizes of this catheter should be in possession of the aurist—respectively 1, 2, and 3 millimetres in diameter. The hard-rubber catheters have the advantage of cheapness, but they are not so easily disinfected as are the metal ones, which can be dropped into water and boiled or sterilized in the steam-sterilizer without injury. Moreover, the hard-rubber instruments have a diameter larger in proportion to the size of their calibre than that of the silver catheters. Sexton has invented a soft-rubber Eustachian catheter which is firm enough to be used without a stylet, and because of its flexibility an instrument of this kind, somewhat larger in diameter, can more readily be introduced through the nose than those made of hard rubber or of metal.

FIG. 47.



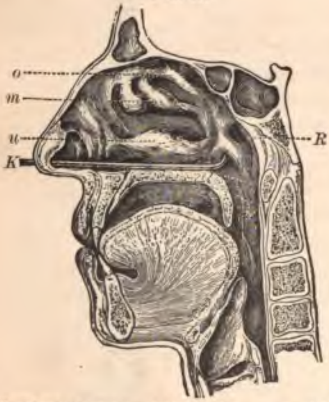
Hard-rubber Catheter.

Describe the methods of introducing the beak of the catheter into the Eustachian tube.

The operator should first inspect the anterior narium of the patient to be catheterized, and carefully note the position, size, and shape of any obstruction, such as a septal exostosis, which will interfere with the passage of the catheter. The operator should hold the proximal extremity of the catheter between the thumb and fingers of his right hand, somewhat in the manner of a pen-holder, and lift up the tip of the patient's nose with the thumb of his left hand. The beak or distal extremity of the catheter is then inserted within the nares, and is made to rest upon the floor of the nose, while the proximal end of the instrument is elevated until it is parallel with the floor of the nose. Still keeping the beak of the instrument in contact with the floor of the nose, the catheter is pushed gently inward until the beak of the instrument is felt to be in contact with the posterior wall of the pharynx. At this stage of the procedure the operator has the choice of the three methods of procedure in common use. Probably the one most frequently employed is that of Löwenburg, who directs that when the beak of the instrument is felt to be in contact with the pharyngeal wall the catheter should be rotated inward through an angle of 45°, and drawn forward until the beak of the instrument is felt to touch the posterior edge of the septum, when it is rotated outward through rather more than an angle of 90°, and should then be in the mouth of the Eustachian tube. The operator may feel satisfied that this is the case if the beak of the catheter is found to be somewhat firmly fixed in the position it has assumed, so that it is impossible to rotate the beak of the instrument upward or carry it backward or forward without exerting considerable force.

Gruber directs that when the beak of the catheter is felt to be in contact with the pharyngeal wall it should be withdrawn until its curved portion comes into contact with the posterior margin of the hard palate. It should then be again pushed inward a distance of about half an inch, and rotated outward toward the ear through an angle of a little more than 45°, when, if these manœuvres have been successful, the beak of the instrument will be within the mouth of the Eustachian tube.

FIG. 48.



Vertical Section of Naso-pharynx, with the Catheter introduced into the Eustachian Tube.

When the beak of the instrument is felt to be in contact with the pharyngeal wall it may be immediately rotated outward 45°, which will carry the beak of the instrument into Rosenmüller's fossa (Fig. 48, R). The catheter should now be drawn gently outward until its beak is felt to slip over the posterior lip and into the mouth of the tube. An operator soon learns by the sensation imparted to his hand whether the beak of the instrument is or is not in the Eustachian tube.

What are the obstacles to catheterization of the Eustachian tubes?

Deviation of the septum to such a degree as almost to completely occlude one nasal chamber may render the passage of an Eustachian catheter through that side of the nose impossible. Under such circumstances both Eustachian tubes may be catheterized by means of a catheter passed through the unoccluded nostril. To reach the tube of the opposite side it will be necessary to have the beak of the catheter somewhat longer than that of the instrument shown in Figure 47.

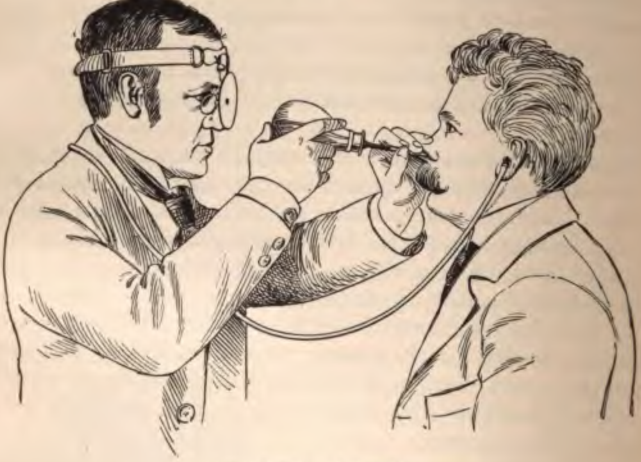
Ecchondroses or exostoses of the septum frequently interfere with the easy passage of the catheter through the inferior meatus of the nose. Under such circumstances the beak of the catheter can sometimes be passed over them, and made to rest upon the floor of the nose or the soft palate behind. In some such instances a soft-rubber catheter can be used to advantage. In passing the catheter through the nose the instrument should be held very lightly between the thumb and finger, and a tendency to rotate on its long axis should not be resisted, because by allowing the instrument to rotate its beak will sometimes glide around an obstruction, and finally find its way into the pharynx.

Another obstacle to catheterization of the Eustachian tubes results from spasmodic contraction of the muscles of the palate and pharynx, which tightly grasp the beak of the instrument and greatly interfere with its proper manipulation. Gentleness and patience on the part of the surgeon will generally overcome this difficulty. The patient should be requested to inhale deeply through his nose or to "swallow," and thus produce a temporary relaxation of the parts, which, if repeated from time to time, will generally enable the surgeon to guide the beak of the catheter into the mouth of the Eustachian tube.

How is Politzer's air-bag used with the Eustachian catheter to inflate the middle ear?

When the beak of the catheter is felt to be within the mouth of the Eustachian tube it should be held in position with the thumb and forefinger of the left hand, and steadied by two fingers resting upon the patient's forehead (Fig. 49). The nozzle of the air-bag is then fitted *loosely* into the proximal end of the catheter and compressed with the right hand. If the auscultation-tube be employed at the same time, air will be heard to enter the patient's middle ear with a sound somewhat similar to that produced by inflating the middle ear by Valsalva's or Politzer's method. However, when the catheter is employed the sound seems as if produced *nearer* the surgeon's ear.

FIG. 49.



Auscultation of the Ear.

EXAMINATION OF PATIENTS.

What is the best method of examination of patients with impairment of the acuteness of hearing?

First listen passively to the patient's account of the origin and nature of his affliction, asking, if necessary, judicious but not leading questions as to the cause of the ear disease, the length of time that it has continued, and the symptoms other than deafness that may be present. In questioning the patient the aurist should bear in mind the effects of "suggestion" upon patients of nervous temperament as regards tinnitus. Many neurotics with disease of the middle ear will experience, for the first time, subjective noises in their ears upon being asked leading questions in regard to tinnitus, and afterward complain of the presence of this symptom, which previous to that time had not attracted their attention.

Careful notes of the patient's history should be made in the case-book, and especial prominence be given to the symptoms of the disease from which he seeks relief.

The hearing should next carefully be tested by the voice, the watch, and the tuning-fork. In making a record of the results of the tests for hearing it is convenient, to facilitate easy reference at a subsequent period, to devote one or more lines in the note-book to each ear, using abbreviations to economize space; for example, as follows:

A. D. (Auditus Dextra) or R. E. (Right Ear).	H. (Hearing).	V.=whisper, 3 ft. (Voice).	W.=$\frac{12}{36}$. (Watch).	T.-F. c_2, vertex best in A. S. (Tuning-fork).	M=$\frac{20}{50}$. (Mastoid).	M. A. $\frac{10}{50}$. (Meatus Auditorius).

A. S. (Auditus (Sinistra) or L. E. (Left Ear)	H. (Hearing).	V. = (Voice).	L. C. 6 ft. (Loud Conversation).	W.=$\frac{24}{36}$. (Watch).	T.-F. c_2. (Tuning-fork).	M.=$\frac{40}{50}$. (Mastoid).	M. A. $\frac{20}{50}$. (Meatus Auditorius).

In the above record of the tests of the hearing-power it will be noticed that bone-conduction, as tested by a c_2 fork, is somewhat impaired for the right ear, and apparently increased for the left, indicating, as previously explained, that there exists in the right ear not only disease of the conducting apparatus, but also impairment of the receptive apparatus. For most cases one tuning-fork, preferably a large c_2 fork, is all that is required; but for reasons previously stated the aurist should be provided with at least five forks— c, c_2, c_3, c_4—which should all be used in testing the hearing in tain cases apparently demanding operative interference, in ord ascertain the probable result upon the hearing.

After the hearing has been tested the aurist should insp parts of the ears made visible by means of otoscopy, carefully the condition of the external auditory canal and drum-head; the membrane be wholly or partly destroyed as the result of or accident, noting the condition of the mucous membrane of the tympanum and other structures that may be visible. In most instances it is advisable to make a diagram or rude drawing of the condition of the tympanum, and in making notes as to the results of otoscopy to give one or more separate lines in the note-book in the same manner as when recording the results of the tests for hearing.

The interior of the nose and naso-pharynx should next be carefully inspected by means of anterior and posterior rhinoscopy, and careful notes be made as to the condition of the mucous membrane covering these parts, the presence of hypertrophies, ecchondroses, exostoses, and deflections of the septum; the condition of the faucial and pharyngeal tonsils and the mouths of the Eustachian tubes. In recording the results of the rhinoscopic examination it is best to devote one or more lines to a record of each nasal chamber in the same manner as when recording the tests for hearing and the results of the otoscopic examination.

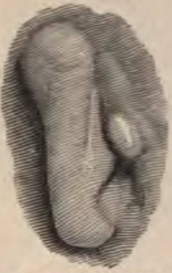
The patency of the Eustachian tubes should next be tested by means of the Politzer method and the aural stethoscope, or, if necessary, the Eustachian catheter should be used. In cases in which patients consult the aurist simply in regard to a disease of the auricle and some cases of disease of the auditory canal, and also in most of the acute affections of the middle ear or mastoid, it is neither necessary nor desirable to make as elaborate an examination as that described above. Dr. Rohrer's diagnostic table, here inserted, although too elaborate for daily use, will be found convenient for reference.

DISEASES OF THE EXTERNAL EAR.

What congenital defects are found in the external ear?

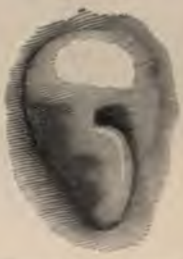
The auricle may entirely be wanting or there may be a plurality of auricles. The auricle may be abnormal as regards position or shape, or it may only be partially developed. Malformations of the auricle are generally associated with defects or absence of the external auditory canal (Fig. 50), and sometimes imperfect development of the deeper portions of the auditory apparatus. A congenital fistula is sometimes seen about the external ear, and may communicate with the tympanic cavity (Fig. 51). Excessive development or lack of development of the external ear is due to excessive or imperfect development in the closure of the first branchial cleft during embryonic life. Various operations have been devised to correct deformities of the auricle and open a way down to the tympanum in cases of stenosis of the external auditory canal. Plastic operations in this locality do well as regards the healing process. Operations for the correction of atresia or stenosis of the external auditory canal hitherto have not been attended by an encouraging degree of success.

FIG. 50.



Congenital Deformity of the Auricle (Sexton).

FIG. 51.

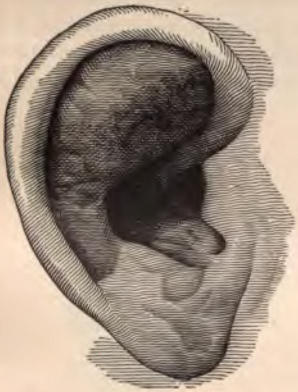


Convoluted Auricle with Congenital Fistula (Sexton).

Describe othæmatoma of the auricle.

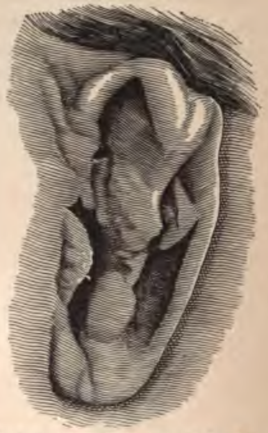
Othæmatoma, or perichondritis, of the auricle (Fig. 52) is generally the result of direct violence—self-inflicted in the insane, amon whom the disease is not uncommon. This affection is characteriz by an effusion beneath the perichondrium of the auricle, causing swelling, tension, and pain in the part. The effusion may finally escape through an external opening which it has made for itself, remain as a swelling for an indefinite time, or slowly be absorbed.

FIG. 52.



Medium-sized Othæmatoma of the Auricle (Sexton).

FIG. 53.



Deformities of the Auricle due to Othæmatoma (Sexton).

Even when reabsorption of the effusion does occur, considerable deformity of the auricle results (Fig. 53).

What is the treatment?

Inflammation should be combated by the application of belladonna ointment, and progressive effusion by painting the affected parts with contractile collodion. If, notwithstanding these measures, the collection of fluid beneath the perichondrium seems to increase, the parts should be aspirated with antiseptic precautions by means of a hypodermic syringe and the fluid withdrawn—a measure that will probably need repetition from time to time. In chronic cases, after all signs of active inflammation have disappeared, the reabsorption of the fluid may be hastened by gently kneading the tumor between the thumb and forefinger, and the application of an ointment composed of equal parts of compound iodine and mercurial ointments.

Describe frost-bite of the auricle.

In cold climates frost-bite of the auricle is by no means uncommon. At first the auricle is cold and numb and sometimes stiff as if actually frozen solid. Later on the symptoms are those of traumatism, involving only the skin or the skin and deeper structures. The skin is hot and swollen, frequently excoriated or covered by vesicles. In the severer cases, the symptoms are those of perichondritis, followed sometimes by cartilaginous necrosis and the formation of sinuses upon either surface of the auricle.

What is the treatment?

When the auricle is frozen its temperature should be restored gradually by gentle friction with snow or pounded ice, and afterward by gentle manipulation with the fingers. If only the skin is involved by the subsequent inflammation satisfactory results will follow the application of a ten per cent. ichthyol ointment in vaseline, which should be applied sufficiently often to keep the parts constantly covered and protected by the ointment. In some cases pain and soreness are greatly relieved by wrapping the auricle in absorbent cotton after using the ointment and applying gentle pressure by means of a bandage. When perichondritis follows frost-bite of the auricle it should be treated in the manner already described. When sinuses have formed, they should be laid open, the necrosed tissues removed, and the wounds allowed to heal by granulation. If care is taken to keep the parts properly supported but little deformity sometimes results.

How should wounds and injuries of the auricle be treated?

Incised and punctured wounds after thorough cleansing should be sutured in such a manner as to leave as little scar as possible upon the lateral surface of the auricle. In contused and lacerated wounds perichondritis almost invariably occurs and it is well to anticipate, such an attack by the application of cold compresses for twelve to twenty-four hours. An attempt should be made to save as much tissue as possible, and no part which possibly may have sufficient vitality to live should be removed. As a primary measure but few sutures should be used, as after the circulation has been thoroughly established it is ordinarily a simple matter to secure more perfect coaptation of the parts and prevent deformity.

How may cleft lobule be remedied?

Cleft lobule, which is generally the result of the tearing out of an ear-ring, may be remedied by the following operation: The sides of the cleft are freshened in the same manner as for a hare-lip operation; but, to avoid as far as possible the formation of a conspicuous scar, the sutures should be introduced and tied on the inner side of the lobule, and should involve only the deeper layers of the skin of its outer surface. After the parts have been accurately adjusted and the sutures tied, the wound should receive further support by the application of iodoform collodion. If the operation be done under antiseptic precautions, it is generally successful, firm union occurring within a few days.

What cutaneous diseases sometimes attack the auricle?

The cutaneous diseases which sometimes attack the auricle are eczema, dermatitis, comedo, erysipelas, syphiloderma, herpes zoster, and lupus.

Describe eczema of the auricle.

Eczema is by far the commonest of the skin diseases affecting the auricle. It may also involve the auditory canal, and even the dermoid layer of the membrana tympani. Intertrigo resulting from the invasion by the disease of the fissure formed by the junction of the auricle with the mastoid region is of frequent occurrence in infants and young children.

What is the treatment?

In adults the disease is sometimes the result of the rheumatic or gouty diathesis, and, in addition to local treatment, such cases require the administration of alkalies, with iodide of potassium, salicylate of sodium, or arsenic. In children the disease is frequently associated with struma, and for such cases cod-liver oil or syrup of the iodide of iron should be prescribed. Eczema intertrigo is best treated by the frequent application of powders, and oxide of zinc or subnitrate of bismuth may be prescribed for this purpose.

The commonest cause of eczema of the auricle in children is an irritating discharge from the middle ear. In the neglected children of the poor the discharges resulting from purulent inflammation of the tympanum are frequently smeared by the fingers of the child over the entire auricle and over the skin in front of and behind the ear.

Under such circumstances the auricle and surrounding skin become covered by eczematous scabs and crusts. These the surgeon should carefully remove by means of pledgets of cotton saturated with peroxide of hydrogen, and rub well into the affected parts an ointment consisting of six or eight grains of the yellow oxide of mercury to an ounce of petrolatum. A single thorough application of this remedy is sometimes sufficient to bring about a cure even in cases in which the disease has existed for several months. Perfect cleanliness in all cases should be enjoined, and if frequent cleansing of the auditory canal with absorbent cotton, followed by insufflations of powdered boracic acid, is not sufficient to keep the concha dry and free from the discharge, the skin of this part of the ear should be protected by some bland ointment. Benzoated-zinc ointment, if *fresh* and properly made, answers very well for this purpose.

What new growths occur upon the auricle?

The new growths that occur on the auricle are sebaceous cyst, fibroid tumor, epithelioma, nævus, sarcoma, and cornu hominum.

What is the treatment?

The treatment is the same as if the new growths occurred elsewhere. Nævi in suitable cases should be treated by electrolysis. The other growths ordinarily require excision.

What are the more common affections of the external auditory canal?

The more common affections of the external auditory canal are acute circumscribed inflammation or furunculosis, acute and chronic diffuse inflammation, diphtheritic inflammation, hyperostosis, exostosis, and foreign bodies.

What is the etiology of acute circumscribed inflammation of the external auditory canal?

Recurrent attacks of furunculosis of the auditory canal seem, in many instances, to be the result of irritation from carious teeth or from disease of the interior of the nose and throat. The affection is commonest in anæmic and debilitated individuals and in women suffering from menstrual disorders.

What is the pathology of the affection?

In most instances a sebaceous gland or a ceruminous follicle is the starting-point of the disease, but in some cases the inflammation begins as a circumscribed perichondritis or periostitis of the auditory canal. The pathology of acute circumscribed inflammation of the external auditory canal is similar to that of boils and felons occurring elsewhere on the body.

What are the symptoms?

There is at first an itching within the canal, a portion of which is found tender to the touch, and soon becomes painful. Little by little the pain and tenderness increase, until in some instances the patient's sufferings become almost unendurable. In severe cases the pain, which at first was confined to the ear, extends to the whole side of the head, is throbbing in character, and is increased by movements of the jaw in talking, eating, etc. There is some elevation of temperature in the severest cases. Deafness is not a marked symptom until the swelling is large enough to close the canal at the part involved, but tinnitus is present in the majority of cases. The furuncle will rupture spontaneously in from two to eight days, according as the inflammation is superficial or deep-seated. The discharge is purulent, sometimes quite profuse; and its appearance is speedily followed by a subsidence of acute pain; the parts, however, remain sore for several days.

What is the treatment?

Speedy relief generally follows a free incision through the swollen parts down to the cartilage or bone, even though no pus be found. The incision should be followed by syringing the canal with hot boric-acid solution and the application of a hot poultice.

In cases where incision is not advisable a cone of cotton should be well covered with an ointment of the yellow oxide of mercury (Formula 21), and so placed within the canal that it will exert pressure upon the swollen parts. For a few moments this procedure increases the pain somewhat, but it is followed by a feeling of decided relief and comfort. The ointment is rubbed into the skin of the canal by each movement of the jaw in talking and eating, and if the treatment is applied early enough, many cases of furunculosis of the auditory canal may be aborted before suppuration has occurred.

Some relief from pain follows the application of a 10 per cent. ointment of cocaine in lanolin or a 1 per cent. ointment of atropia. Heat, however, generally gives speedy relief from pain. It may be applied by gently syringing the canal with hot water, by the application of a poultice, or by resting the head upon a hot-water bag or a bag of hot salt or of hops. In severer cases it is advisable to secure a free evacuation of the bowels by means of small, frequently-repeated doses of calomel and bicarbonate of sodium. Drop-doses of tincture of aconite-root, repeated every hour, will control to a certain extent fever and pain. In all cases the cause of the attack should carefully be sought, and measures adopted to prevent a recurrence.

Describe otitis externa diffusa acuta.

Diffuse inflammation of the auditory canal varies in character from a simple erythema of the skin of the auditory canal to severe periostitis. The disease usually attacks the osseous portion of the canal, but it may extend to the auricle, and, by periosteal continuity, to the periauricular and mastoid regions, causing abscess and necrosis.

What is the etiology of otitis externa diffusa acuta?

The disease usually occurs in persons whose general health is impaired. It is sometimes consecutive to an attack of otitis media acuta, or it may be caused by an irritating discharge from the middle ear. The affection, which usually begins in the skin or cellular tissue, may extend to the periosteum and bone.

What are the symptoms?

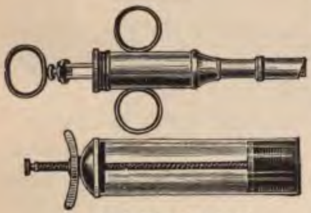
The symptoms are similar to those of furuncle of the auditory canal, except that the pain is usually more intense and appears at an earlier stage of the disease, while deafness and tinnitus are more marked and long continued. On inspection the tissues of the auditory canal appear red and swollen. The swelling is usually greatest in the bony portion of the canal, where it may be so great as to completely obliterate the canal and prevent a view of the drum-head from being obtained. Generally the skin is excoriated at points where the inflammation is greatest, and usually there is desquamation and a slight watery discharge.

What is the treatment?

Incision of the swollen tissues is rarely necessary unless an abscess has formed. Pain can generally be alleviated very much, if the case is seen early, by the application of a large leech to the skin in front of the tip of the mastoid, as closely as possible beneath the auditory canal. Two leeches may be applied in front of the tragus, or Lüer's artificial leech (Fig. 54) may be used in this position.

This instrument is of great service in the abstraction of blood in deep-seated inflammation. The scarifier has a circular cutter, passing through the centre of the shaft, the depth of the cut being regulated and set by a thumb-screw. After making the incision the blood is drawn by the pump, consisting of a glass barrel and a piston, with a screw arrangement to fix it when drawn up. The glass cylinder, which holds about one ounce of blood, should be filled in from three to four minutes. The piston should be soaked in warm water previous to the operation, so that it may swell up and fit the tube tightly, and the edge of the latter, which is applied to the skin, should be greased or soaped, in order that it may fit closely to the skin and prevent entrance of air.

FIG. 54.



Lüer's Artificial Leech.

In many cases it will be necessary to prescribe morphia to completely control the pain and secure sleep; but *heat*, applied in the manner already described, will be all that is necessary in the majority of instances. When the acute symptoms begin to subside, ointment of the yellow oxide of mercury should be applied once or twice a day to the swollen tissues by means of a camel's-hair brush. If, however, there is considerable secretion of a watery discharge, the canal should be carefully dried with absorbent cotton, and the parts be painted with a solution of nitrate of silver (Formula 29) and dusted with powdered boracic acid.

What is the etiology of otitis externa diffusa chronica?

This disease occurs in individuals whose health is impaired, or it may be the result of the gouty or rheumatic diathesis or the irritation caused by carious teeth or disease of the nose and throat. The growth of *Aspergillus* within the inflamed canal must be regarded as a complication rather than a cause of disease.

What are the symptoms?

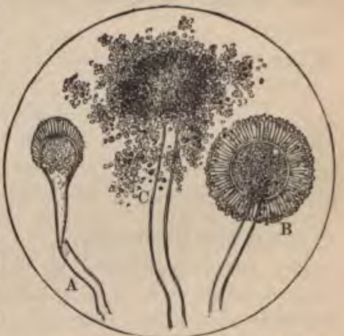
Patients complain of itching and a sense of heat within the canal. Pain is usually absent, except during acute exacerbations. Upon inspection the skin of the auditory canal is found to be red and swollen, especially in the deeper portions. The inflammation may be of the eczematous or desquamative type, and accompanied by a watery discharge or seborrhœa.

What is the treatment?

The cause of the affection should be carefully sought. Patients of the strumous diathesis or in feeble health will require the administration of cod-liver oil and tonics, and appropriate remedies should be prescribed for those in whom the disease seems to be the result of the rheumatic or gouty diathesis. If carious teeth are present, they should receive the attention of a skilful dentist, and any disease of the nose or throat that may be present should be properly treated. The local treatment of chronic diffuse inflammation of the external auditory canal varies according to the stage and variety of the disease present. When the disease is of the eczematous type, all scales and scabs should be removed by means of a pledget of absorbent cotton wrapped about a probe and dipped into a solution of the peroxide of hydrogen (Formula 10), and yellow oxide-of-mercury ointment (Formula 21) well rubbed into the parts. When there is considerable secretion of watery fluid the canal should be dried thoroughly and brushed with a solution of nitrate of silver (Formula 29), and kept dry by frequent insufflations of boracic acid.

If a growth of *Aspergillus* be present, the fundus of the canal will be found filled by a pasty, whitish material, interspersed with black spots, and the use of the microscope will detect the presence of either or both the *Aspergillus glaucus* (Fig. 55, A, B) and the *Aspergillus niger* (Fig. 55 C). These two species of *Aspergillus* are the commonest fungi found within the auditory canal, but other varieties are occasionally met with.

FIG. 55.



A, Aspergillus glaucus; B, Aspergillus niger; C, ripe fructiferous head of Aspergillus niger throwing off spores (Burnett).

When *Aspergillus* is present, the canal should be cleansed thoroughly each day with peroxide of hydrogen, and an application made of a solution of nitrate of silver (Formula 29) or of absolute alcohol (Formula 14). It is essential that the canal should at all times be kept absolutely dry, because nothing more favors the growth of *Aspergillus* than moisture. Discharges should be absorbed by the application of powdered boracic acid or a mixture of powdered boracic acid and iodoform (Formula 18).

Describe otitis externa diphtheritica.

Diphtheritic inflammation of the integument of the external auditory canal is an inflammation characterized by the presence of a pseudo-membrane, which when removed leaves a bleeding surface. The pseudo-membrane may or may not contain the Klebs-Löfler bacillus, characteristic of true diphtheria, as other bacteria are capable of causing a diphtheritic membrane within the auditory canal and upon mucous surfaces.

What is the etiology?

The disease occurs usually as a complication of diphtheria of the throat and middle ear. Primary diphtheria of the walls of the external auditory canal has been observed during epidemics of diphtheria.

What are the symptoms?

In the primary form there are deafness and tinnitus, with slight pain. Examination discloses the presence of the characteristic diphtheritic pseudo-membrane. The secondary form of the disease frequently causes destruction of the membrana tympani, necrosis of the ossicles and portions of the temporal bone.

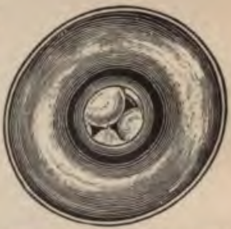
What is the treatment?

The pseudo-membrane should be removed thoroughly by the surgeon twice each day, by means of a 50-volume solution of the peroxide of hydrogen (Formula 10), and the parts be kept as dry as possible by the insufflation of powdered boracic acid. If treated in this manner, the pseudo-membrane usually does not re-form after the third or fourth day.

What are exostosis and hyperostosis of the external auditory canal?

Up to a comparatively recent date the name "exostosis" was applied to all bony outgrowths within the auditory canal. At the present time, however, the name is restricted to bony growths at the junction of the cartilaginous and bony portions. Exostoses of the meatus are usually single and pedunculated. Hyperostoses are situated at the inner end of the meatus close up to the membrane, are sessile, and generally multiple (Fig. 56). Both exostoses and hyperostoses upon examination appear as whitish prominences, which are found to be firm and hard when touched with a probe.

FIG. 56.



Hyperostoses seen through an Ear-speculum (Dalby).

What is the etiology?

Hyperostoses in most instances are probably congenital, and in all cases their presence and growth are painless, while an exostosis is always preceded by inflammation. A subperiosteal abscess forms over the mastoid, the pus finding its way into the meatus at the junction of the cartilaginous and bony portions of the canal. The mouth of the sinus in this position becomes occupied by exuberant granulations from the bone, which in the course of time gradually become converted into bone.

What are the symptoms?

Hearing is not impaired unless the bony growth or growths are large enough to entirely block the lumen of the meatus. The smallest opening is sufficient to transmit sound-waves. If, however, such a small opening is occluded by a drop of fluid or by a few scales of epithelium or by a small mass of cerumen, the hearing at once is greatly impaired. The presence of hyperostoses will, when purulent disease of the middle ear is present with perforation of the drumhead, greatly interfere with drainage and render the disease difficult to cure.

What is the treatment?

If an exostosis is large and attached by a rather small pedicle to the auditory canal, especially if the growth be slightly movable, it can readily be detached by means of a small chisel and extracted with a pair of forceps. Exostoses of this character should always be removed.

Hyperostoses are best let alone, even in those cases in which they encroach upon the canal to such an extent as to decrease greatly its lumen. If from time to time the patient becomes deaf from an accumulation of cerumen between the hyperostoses, this should be picked carefully away by means of an appropriate instrument. The syringe should *not be used*, because it is often impossible to remove fluid from behind the exostoses after syringing, and it may be the cause of an inflammation of the auditory canal and drum-head exceedingly difficult to control. Where the presence of hyperostoses seriously interferes with proper drainage in cases of purulent otitis, an attempt should be made to effect a removal of one or more of the growths by means of a drill propelled by an electric motor. In some cases the lumen of the canal may be increased by the use of a soft-rubber tube inserted between the apices of the hyperostoses, the expansion of which tube causes a gentle and even pressure, and may cause the partial absorption of the growths. Applications of iodine and ointments containing mercury are worse than useless.

What foreign bodies are found in the auditory canal?

Animate and inanimate objects, impacted cerumen, laminated epithelial plugs.

What animate objects are sometimes found in the auditory canal?

Flies and other insects, the larvæ of insects, and various moulds.

What is the treatment?

The treatment when the auditory canal is invaded by a growth of *Aspergillus*, *Mucor*, or other moulds has already been detailed (p. 79). Insects can generally be removed readily by means of the syringe. The larvæ of insects are not usually present unless there be suppuration of the middle ear, but cases have been reported of the presence of maggots within the auditory canal when the drum-head was intact and no suppuration existed. Larvæ can be killed with chloroform vapor, and then removed by means of the syringe.

What inanimate objects are sometimes found in the auditory canal?

Shoe-buttons, pebbles, glass beads, the ends of lead- and slate-pencils, and other objects are sometimes placed by children within their ears in a spirit of mischief. It is not rare for aurists to find parts of an onion or pieces of cotton that were placed within the auditory canal by patients perhaps months or years before and forgotten. Among the foreign bodies may be classed impacted cerumen and laminated epithelial plugs.

How should foreign bodies be removed?

Leaves of the onion, wads of cotton, and other soft objects are readily grasped by mouse-toothed forceps and extracted. Hard, round objects, such as shoe-buttons and glass beads, should at first be attacked by means of a syringe. A fine canula should be placed in such a position that a stream of fluid can be thrown into the auditory canal past the object. If careful syringing in this manner fails to dislodge the foreign body, a delicate hook should be introduced into the canal flatwise between its wall and the object, and an effort made to *roll* the object outward through the canal. Hard, irregularly-shaped bodies, that cannot be grasped by the forceps, will often tax the ingenuity of the surgeon to effect their removal. Efforts at removal should be made with extreme gentleness, for fear of injuring the drum-head, and the surgeon should bear in mind that rather than incur the risk of doing so it is preferable to detach the auricle from the bony meatus by means of an incision made posterior to the auricle, and turn the auricle and cartilaginous meatus forward upon the cheek. By this measure the operator is brought nearer to the foreign body and considerable space is gained for manipulating the instruments. The auricle can readily be readjusted to its place, and so secured by sutures as to prevent any deformity after the wound is healed.

In children it is generally necessary to give an anæsthetic, so as to secure that perfect quiescence of the patient necessary for the delicate and careful manipulation of instruments. In difficult cases it is best not to prolong unsuccessful efforts to remove a foreign body, for often it will remain in the auditory canal for years without producing any serious symptoms. In cases where it has been impossible to remove the foreign body at the first sitting the canal should carefully be syringed each day, and after all swelling of the auditory canal has subsided efforts for the extraction of the foreign body will finally prove successful.

Cases in which the uninitiated, by injudicious and uns
efforts to remove a foreign body, have ruptured the dr

brane and caused acute purulent inflammation of the middle ear, and in which so much swelling of the canal has arisen that nothing can be seen, should be treated by frequent syringings with warm water and by hot fomentations, until the inflammatory symptoms have subsided and the foreign body can be seen. No attempt at its removal should be made until every particle of swelling has subsided and the speculum can be used without causing pain. In many such cases it will be found that careful and daily syringings will suffice to remove the object.

What are the subjective symptoms of impacted cerumen?

The patient usually complains that he has suddenly become deaf in one ear without any previous symptoms. The explanation of this fact is that so long as there is the smallest conceivable opening through a mass of cerumen it will be sufficient to transmit sound-waves, and the hearing will not be greatly impaired. Sometimes a small opening through a mass of cerumen will close from time to time during damp weather, and open again when the atmosphere becomes dry. This phenomena may be repeated many times, the patient being only deaf during damp weather. Even when impacted cerumen is present in both auditory canals the patient usually becomes deaf in one ear first. Under such circumstances the larger amount of inspissated cerumen may be removed from the ear in which the hearing is the most nearly perfect.

What is the etiology of impacted cerumen?

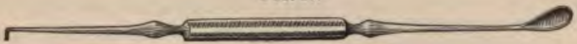
Increased secretion of cerumen is usually the result of disease of the middle ear or of catarrh of the nose and throat. It is rather unusual to find the hearing perfect after the removal of a mass of impacted cerumen. The introduction of irritants within the auditory canal increases the secretion of cerumen.

What is the treatment?

If the mass be soft, syringing with warm water will quickly remove it, inspissated cerumen being soluble in water. If, however, the accumulation is very hard and dry, and is mixed with a considerable proportion of epithelial scales, the mass may be softened by directing the patient to fill the canal with warm water several times a day before efforts at removing the mass is attempted. This plan is probably advisable for those who have had little experience with the manipulation of instruments within the auditory canal. Although inspissated cerumen is perhaps as readily soluble in water as any other bland fluid except peroxide of hydrogen, olive oil or a mixture of water, glycerin, and bicarbonate of sodium is sometimes prescribed, to be dropped into the ear several times a day, to soften inspissated cerumen before efforts are made to extract the mass by syringing.

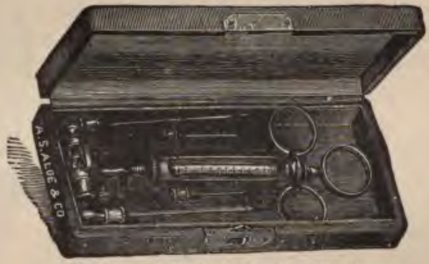
When the impacted cerumen is very hard and firmly fixed within the auditory canal, it is probably best not to attempt to remove it by syringing until it has either been softened as described above or the mass has been rendered movable by manipulation with instruments. For this purpose the tip of an Allen steel probe, bent at a right angle, or the hooked end of a Gross ear-spoon (Fig. 57), should be introduced flatwise between the wall of the canal and the cerumen until it has penetrated a short distance, when the hook should be turned into the mass of cerumen and gentle traction exerted. Generally there will be detached a small portion of the impacted cerumen, which can easily be removed from the canal. Proceeding carefully in this manner, it is sometimes possible to remove, even in those cases in which the wall of the canal is very sensitive, the en
mass of impacted cerumen without causing even the slightest
or congestion of the drum-head. It is, however, best to de

FIG. 57.



Gross's Ear-spoon.

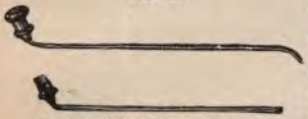
FIG. 58.



Convenient Syringe for Ear Work.

soon as the mass of cerumen is felt to be movable and resort to the syringe. For this purpose a small syringe, holding not more than 2 drachms, is amply sufficient (Fig. 58). The stream of fluid should be thrown behind the impacted cerumen through the opening that has been made by an instrument. One or two syringefuls of warm water will probably suffice to remove the greater portion of the cerumen, after which the auditory canal should carefully be cleansed of any remaining flakes by a dossil of absorbent cotton wrapped about the end of an Allen probe and dipped into a solution of peroxide of hydrogen.

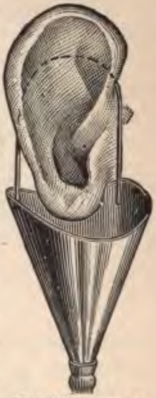
FIG. 59.



Blake's Middle-ear Canula.

It is perhaps needless to mention that the manipulation of the mass of impacted cerumen and the subsequent syringing should be done under perfect illumination by means of a concave reflector (Fig. 26). It is generally unnecessary to employ a speculum. A metal ear-spout (Fig. 60) will be found convenient to receive the fluid from the auditory canal during the syringing.

FIG. 60.



Metal Ear-spout.

What is keratosis obturans?

The name "keratosis obturans" was applied by Weeden of St. Petersburg to epithelial laminæ impacted within the auditory canal in contradistinction to "cerumenosis obturans," or impacted cerumen. In many masses of impacted cerumen there are more or less epithelial laminæ. The typical laminated epithelial plug, however, consists almost entirely of laminæ of epithelium packed one about the other. The external end of such a mass is generally covered by inspissated cerumen, which of course is easily removed by syringing, when the laminæ of closely-packed epithelial scales are exposed to view, looking not unlike a plug of wet chamois skin. It is impossible to remove such an accumulation by syringing. It is necessary to effect its removal, layer by layer, by means of a hook, a curette, or by forceps. A laminated epithelial plug is composed of the horny layer of the cutis of the auditory canal, which accumulates, layer by layer, within the canal as the result of desquamative inflammation. After the removal of a laminated epithelial plug the membrana tympani will probably be found normal in appearance and the hearing be perfect. This is not the case when the collection within the canal consists of a cholesteatomatous mass.

What is aural cholesteatoma?

The name "aural cholesteatoma" is sometimes applied to a true new growth within the temporal bone, similar to cholesteatomata found in other bones of the skull. Ordinarily, "cholesteatomatous mass" means an accumulation within the auditory canal and tympanum of a mass consisting of epithelial scales, cholesterine crystals, and inspissated pus, derived by desquamative inflammation from the lining membrane of the tympanum or mastoid cells.

The presence of cholesteatomatous masses usually causes impaired hearing, tinnitus, and sometimes nausea and dizziness. The bony structures often become carious as the result of the pressure caused by the accumulation of cholesteatomatous material, while the soft parts ulcerate from the same cause; so that cholesteatomatous accumulations are sometimes found occupying large cavities—so large, indeed, that in one instance the cavity from which a cholesteatoma was removed involved the greater part of the auditory canal, the whole of the tympanum, and a large part of the mastoid and petrous portion of the temporal bone.

Small collections of cholesteatomatous material are common at the upper and posterior portion of the auditory canal in cases in which perforation of Shrapnell's membrane has occurred. The mass often extends into the attic of the tympanum, sometimes into the mastoid antrum; and often causes somewhat extensive destruction of the bone and other tissues. Cholesteatomatous masses are usually not easily detected at the first glance. Sometimes a small mass projecting into the meatus will be the only evidence of the presence of a cholesteatoma of considerable size. If, however, the small mass projecting into the canal be removed, other masses will be found, until in some instances a cavity of considerable size will have been emptied of its contents. The beginner in otology should be on the lookout for accumulations of this kind, and should not consider his otoscopy completed in any given case until all visible parts have received the closest scrutiny and been thoroughly cleansed.

What is the etiology of aural cholesteatoma?

When the membrana tympani is perforated as the result of disease or operative interference, the opening in the drum-head generally promptly closes. If, however, a large portion of the drum-head is destroyed as the result of long-continued suppuration, the epidermis of the canal proliferates over the margins of the perforation and prevents its being filled by granulations; so that the perforation tends to become permanent. Furthermore, under certain conditions the epidermis of the canal proliferates over the walls of the cavities of the middle ear, and a greater or less extent of surface assumes a skin-like character and appearance. The entire tympanum, aditus and antrum may become epidermized, but generally the epidermis extends but a short distance into the tympanum.

When the attic and antrum become epidermized their lining membrane exfoliates, generally as the result of chronic inflammation, and epidermic scales accumulate unless removed until the entire cavities become filled, as shown in Figs. 89 and 90.

Occasionally the presence of a small collection of cholesteatomatous material in the attic will cause a small amount of discharge through a fistula over the drum-head, and this scanty discharge, drying almost as it is secreted, sometimes forms closely adherent casts of the drum-head that might easily be mistaken for the drum-head itself. The removal of such casts from the drum-head is generally followed by considerable improvement in the hearing.

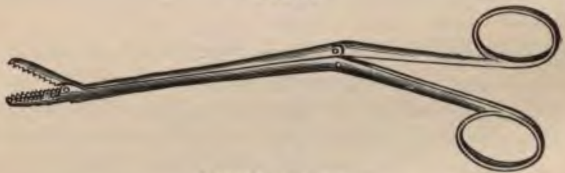
Although Toynbee refers to collections of cholesteatomatous material under the name of "pearly or molluscous tumors," and evidently thought that they were derived from the epidermis of the auditory canal, and Hinton, Kupper and Wendt refer to similar collections derived from the epidermis of the drum-head, yet the majority of authors who wrote previous to the last decade taught that cholesteatomata were due to the retention of the products of inflammation of mucous membranes. The fact that cholesteatomata are not infrequently found within the middle ear when the drum-head is intact and there is no communication between the auditory canal and the cavity containing the mass seemed to favor this view, but it should be borne in mind that perforations of the drum-head may persist for years and finally close.

DISEASES OF THE MEMBRANA TYMPANI.

When inspecting those parts of the ear visible by otoscopy, to what should the attention of the observer be particularly directed?

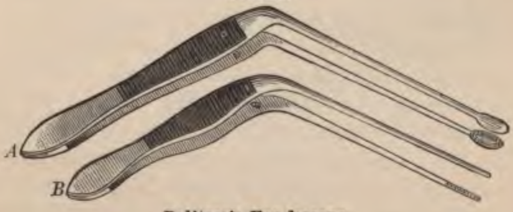
First, the size of the auditory canal and the condition of its wall. Every little scale of epidermis or mass of cerumen that can possibly hide an abnormal condition should carefully be removed by means of a cotton-tipped probe. The observer's eye should next seek the umbo or depression near the centre of the drum-head, and the glance should then be directed upward along the handle of the malleus until Shrapnell's membrane is brought into view. This portion of the membrane should receive the most careful scrutiny, an effort being made to discover, if possible, the presence of the so-called "foramen of Rivini" or anything abnormal in this region. Attention should next be directed to the condition of the anterior and posterior folds, after which the glance of the observer should be

FIG. 61.



Noyes's Ear-forceps.

FIG. 62.



Politzer's Ear-forceps.

directed around the periphery of the drum-head. By observing always this or some other definite plan of examination during otoscopy it will hardly be possible that any abnormal condition of importance will escape observation.

Particular attention should be directed to the size, shape, and position of the cone of light, the apparent length and position of the malleus handle, and the degree of prominence of the short process; the color, lustre, apparent thickness, curvature, and position of the drum-head; as well as the presence or absence of perforations, cicatrices, chalk deposits, localized spots of atrophy or thickening, polypi, abscesses, exudation-cysts, or other pathological conditions.

What changes occur in the curvature of the membrana tympani?

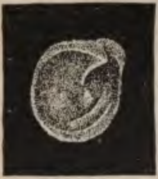
The membrana may bulge outward as the result of pressure from fluid within the tympanum, or there may be a localized "pointing" of pus at any position on the drum-head. The normal curvature of the drum-membrane depends largely upon the tension of the tensor tympani muscle. It is claimed that the retractile effect of this muscle is increased after death by rigor mortis, and in certain conditions the muscle is constantly contracted during life to an extreme degree.

An unduly depressed condition of the membrana tympani also occurs as the result of unequal pneumatic pressure upon its two surfaces, when obstruction of the Eustachian tube interferes with the proper ventilation of the tympanic cavity. Sometimes the retraction of the membrane is quite abrupt at points near the periphery, so that a sort of terrace is formed at that point. Under such circumstances a bright line will be seen at the point where the abrupt change of curvature occurs. Should such an abrupt change of curvature occur at the position of the cone of light, it will appear as if broken transversely into two parts, that nearest the periphery assuming a crescentic shape. Whenever the membrane is retracted as a whole, there is usually some change in the light spot. It often loses the triangular form because of which it has received the name "cone" or "pyramid of light," and becomes narrow, reduced to a mere point, or perhaps entirely disappears.

The posterior fold becomes large and prominent when the drum-membrane is greatly retracted and the malleus handle foreshortened

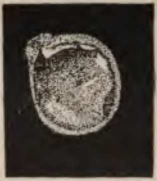
(Fig. 63) or displaced, usually backward (Fig. 64). The two diagrams, after Randall (Figs. 65 and 66), represent the means by which the apparent shortening of the malleus handle is produced.

FIG. 63.



Retracted Membrane, showing foreshortening of malleus handle, prominence of the posterior fold, and visibility of the margin of the pocket of Von Troelsch as it passes forward to the manubrium. The light spot is shortened, and beyond it anteriorly are two parallel curvilinear bright lines, marking the edges of abruptly depressed areas of the drum-head, one within the other. (From a girl of ten years, with long-standing nasal and tubal obstruction: Randall.)

FIG. 64.



Left Membrana Tympani of a boy of six years with nasal and tubal obstruction. Manubrium drawn up almost out of sight, the tip being higher than the short process; behind it the incudo-stapedial joint is visible, and below and posteriorly the dark niche of the round window is discernible. There is a faint reflection of light near the normal position, and a stronger one on the promontory near the stapes (Randall).

FIG. 65.

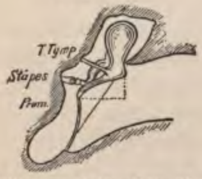


Diagram of Normal Position of Membrana Tympani, showing the inclination of the manubrium and upper segment to the axis of the auditory canal (Randall).

FIG. 66.

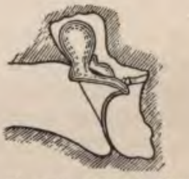


Diagram of a Retracted Membrana Tympani, showing the manubrium drawn almost directly inward (Randall).

What is myringitis?

Myringitis is an inflammation of the membrana tympani, characterized by congestion, swelling, and sometimes ulceration of the membrana tympani, pain, and tinnitus; but hearing is not greatly impaired unless the inflammation also involves the entire tympanic cavity. The pain is increased by movements of the jaw, pressure in front of the tragus, or traction upon the auricle; it is generally shooting rather than throbbing in character.

What is the etiology?

The commonest cause of myringitis is exposure to cold, especially the direct impact of a cold wind upon the membrana tympani in persons whose auditory meatus is unduly open. It is sometimes the result of direct violence, as, for example, a blow upon the auricle or the impact of a wave in surf-bathing. In some cases the etiology is obscure, and the disease seems to be the result of struma or of the rheumatic or gouty diathesis.

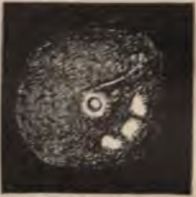
What are the symptoms?

Severe pain, shooting in character, tinnitus, and more or less deafness. Upon inspection, if the disease is seen in its earlier stages, the membrane will be found markedly congested at the periphery and behind the malleus handle. Large vessels will be seen in these positions, and radiating branches will extend from the blood-vessels behind the malleus handle to inosculate with those coming from the periphery. The surface of the membrane becomes lustreless and rough from loosening of its epithelium, and thick and opaque and of a uniform reddish color from infiltration and increased congestion, until all landmarks except the short process of the malleus handle are hidden from view, this too finally disappearing beneath the swelling, the membrane being, at this stage of the disease, of a lively red color and apparently either flat or actually convex in form. As the integument in the neighborhood of the drum-head is also congested, it is difficult to make out its boundaries, the red and convex membrane appearing not unlike a polypus projecting into the canal, for which it has been mistaken.

In the course of the disease the epidermis exfoliates, wholly or partly, and there appears an abundant secretion, which is at first sero-sanguineous, but later becomes purulent. Exudation-cysts, filled with serum or with pus, sometimes appear upon the surface of the drum-head. Pressure with a probe will indent such collections of fluid between the layers of the drum-head, and the indentation will remain visible for some time (Fig. 67), which is not the case in localized pointings of pus from within the tympanum. If abscesses rupture or are incised, ulcers result, which may either heal or cause perforations of the drum-head.

As the inflammation subsides the portion of the membrane at the umbo is the first to resume its normal appearance. The periphery of the drum-head and a triangular portion, whose base includes Shrapnell's membrane and whose apex is at the tip of the malleus handle, remain red and swollen for some days. Finally, the swelling and congestion disappear from these parts of the membrane, the light spot becomes distinct, and the drum-head assumes its normal appearance.

FIG. 67.



Interlamellar Abscesses of Right Membrana Tympani, one at umbo showing the pitting caused by pressure of a probe. Three others are seen down and forward (Schwartze).

Relapses are not of unfrequent occurrence, or an acute attack may assume the chronic form of the disease. Chronic myringitis sometimes occurs independently, the only symptom being progressive deafness and itching and a feeling of fulness within the ear. Ordinarily the disease is only part of an inflammation involving the auditory meatus and tympanum. Abscesses sometimes result in perforation, and polypoid outgrowths from the tympanum occur in chronic myringitis, while a more or less offensive discharge is frequently present.

What is the treatment?

In acute cases pain may be relieved by the application of leeches or the artificial leech in front of the tragus, and afterward by the use of hot fomentations. When a discharge appears the parts should be thoroughly cleansed by means of a dossil of cotton dipped into peroxide of hydrogen, and the membrane should be covered with a thin coating of powdered boracic acid. In traumatic cases the pain and congestion rapidly subside under drop-doses of tincture of aconite-root administered every hour. A 4 per cent. solution of cocaine should meanwhile also be dropped into the auditory canal sufficiently often to keep the parts moistened until the pain subsides.

For the more chronic cases, that seem to result from a rheumatic or gouty diathesis, alkalies, with iodide of potassium or salicylate of sodium, should be prescribed, while for cases where the disease seems to result from struma or debility the use of tonics and cod-liver oil and the employment of hygienic measures should be advised.

From what causes may rupture of the membrana tympani result?

From the direct impact of a foreign body or from the instruments used in extracting a foreign body. Many cases are the result of the sudden compression of the air in the auditory canal produced by falls or blows upon the ear or the discharge of large cannon when the patient occupies a position near the mouth of the gun, etc.; and when the membrane is diseased, from the use (abuse) of Politzer's air-douche, or even from violently blowing the nose.

What are the subjective symptoms of rupture of the membrana tympani?

The subjective symptoms are sudden deafness, tinnitus, vertigo, and hemorrhage or a serous discharge from the ear.

What is the prognosis?

The prognosis as regards the restoration of hearing depends largely upon the amount of damage done to the other structures of the ear. Most uncomplicated cases recover satisfactorily and speedily, but sometimes purulent inflammation of the middle ear follows as the result of the injury or as the result of injudicious treatment.

What is the treatment?

Cleanse the external auditory canal carefully, so as to remove all blood-clots or other material that might exert a septic influence. Use Politzer's air-douche if necessary to remove blood from the middle ear or little shreds that might otherwise remain between the edges of the wound and retard union; apply by means of the powder-blower a thin layer of boracic acid upon the drum-head, and *let the ear entirely alone* until the healing process is complete, unless pain or the appearance of a purulent discharge renders further interference necessary.

What is the etiology of perforation of the membrana tympani?

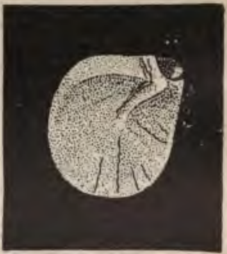
Perforation of the membrana tympani sometimes occurs as the result of traumatism or of ulceration from the dermic surface of the drum-head during an attack of acute myringitis. Under such circumstances the ulcer is usually *central*. The commonest cause, however, of perforation of the membrane is ulceration from within, the result of otitis media purulenta.

What are the symptoms of perforation of the membrana tympani?

Examination by means of the concave mirror and speculum usually discloses the presence of the perforation, which, if large, is readily seen. In most cases inflation of the middle ear by the Politzer method produces a characteristic "perforation whistle," readily heard by means of the auscultation-tube (Fig. 45). Indeed, the "perforation whistle" is often so loud that it can be heard at a distance of many feet from the patient. If suppuration of the middle ear is present, pus will escape through the perforation in the form of bubbles during inflation.

The subjective symptoms vary according to the size and position of the perforation and other diseased conditions of the ear that may be present. A perforation of Shrapnell's membrane (Fig. 68), when it has been present for some time, is usually accompanied by considerable hardness of hearing, because purulent inflammation of the attic, the commonest cause of perforations in Shrapnell's membrane, generally involves sooner or later the articulations of the ossicles and produces lesions which greatly impair the acuteness of hearing. When the perforation is near the centre of Shrapnell's membrane the neck of the malleus is exposed, while perforation through the anterior portion of this part of the drum-head, being directly over the tympanic extremity of the Eustachian tube, yields a loud perforation whistle. Rivini has described a perforation or foramen as existing in the membrani flaccida as a normal condition. Although such a "foramen" is frequently seen just above the short process, it is believed by most aurists to be pathological.

FIG. 68.



Right Membrana Tympani of a boy of five years, with constant discharge for three years. A perforation about 1.5 mm. in diameter is with difficulty seen above the short process, and intra-tympanic injections bring away epithelial flakes and masses of fetid secretion. The rest of the membrane is slightly opaque, thickened, and injected (Randall).

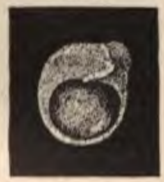
When a large perforation in the membrana vibrans involves a considerable part of the malleus handle, the tip of this process is usually destroyed by necrosis; should, however, the malleus handle become attached to the promontory, this result does not occur. Large perforations may exist in the membrana vibrans without the hearing being greatly impaired, unless the perforation be so placed as to impair the support that the membrana normally gives to the ossicles.

What is the prognosis as regards perforations of the membrana tympani?

Perforations of considerable size permit free access of dust, cold, moisture, and other irritants into the tympanic cavity, and predispose the patient to recurring attacks of otitis media. Sometimes the perforation gradually becomes closed by cicatricial material. Indeed, nearly the whole drum-head may be replaced in this manner. But, although the tympanic cavity is by this means protected from cold or dust-laden air, *the acuteness of hearing* is generally more or less impaired if the surface of cicatricial tissue be large.

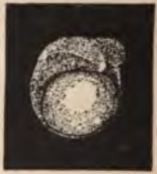
When seen by reflected light cicatricial areas generally appear somewhat depressed below the level of the rest of the drum-head, and they are sometimes so transparent that the structures within the tympanum are readily discernible through them (Fig. 69). If rarefaction of the air within the auditory canal is produced by means

FIG. 69.



A large rounded loss of substance of the membrana tympani below reaches up to the tip of the manubrium, which projects slightly into the upper margin. It is closed by a delicate cicatrix applied to the promontory and moulded upon its inequalities. The edges of the depression are sharp-cut and overhang, so that the area seems an unclosed perforation (Randall).

FIG. 70.



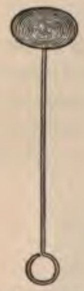
Inflation of the middle ear forces the delicate cicatrix out like a bubble into the meatus, where it seems larger than the opening and hides its edges and the handle of the malleus. In a few minutes the distended sac loses its tension, and becomes plicated as it collapses, soon to resume its old position in contact with the inner tympanic wall (Randall).

of Siegle's pneumatic speculum, a cicatrice will be seen to move farther outward than the rest of the membrane. When large and very thin and lax, a "ballooning" of the cicatrice results from inflating the middle ear by means of Politzer's air-douche (Fig. 70).

What is the treatment?

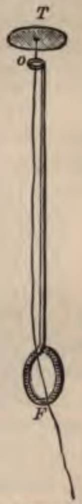
When there is no discharge from the tympanum the perforation is best let alone. The patient should, however, be directed to wear a piece of absorbent cotton within the meatus to prevent the entrance of dust and the too rapid evaporation of moisture from the surface of the tympanic mucous membrane. When the perforation is so large that the support of the tympanic membrane to the ossicles is destroyed, the chain of small bones tends to sag outward by its own weight, and the acuteness of hearing is considerably impaired. If the Toynbee artificial membrana tympani (Fig. 71) be so placed as to give the requisite amount of support when this condition exists, considerable improvement of the acuteness of hearing will result. Little disks of paper, linen, silk, or compressed cotton answer a still better purpose, and a thread should be passed through the centre of such a disk to facilitate its removal from the auditory canal. Gruber has contrived an apparatus (Fig. 72) for the introduction of such artificial drum-membranes by the patient himself, who, after a little primary instruction, can usually introduce one in a manner to secure the greatest increase of the hearing-power. It is astonishing how tolerant the ear sometimes becomes to the presence of such objects, which can often be used for a long time without any deleterious results. It is not a matter of indifference as to the material employed in the manufacture of the artificial drum-heads. Some patients hear best with disks made from one material, some with those made from another.

FIG. 71.



Toynbee's Artificial Drum-head.

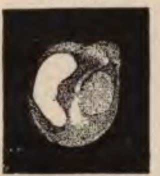
FIG. 72.



Contrivance for introducing artificial drums (Gruber).

When a large cicatrice is present which bulges greatly after inflation—*i. e.* is very freely movable—the hearing can often be improved greatly by the application of a small quantity of contractile collodion (Formula 26). The collodion is best applied by means of a small camel's-hair brush after the inflation of the tympanum. The application of collodion should not be repeated at too frequent intervals or too much applied at one time, because pain and myringitis may result.

FIG. 73.



Right Membrana Tympani, showing an oval cicatrix closing a perforation in front of the manubrium. Posteriorly a large crescentic mass of chalk occupies the entire thickness of the membrane and stands out above it on both surfaces. (From a preparation of Politzer's in the College of Physicians, Philadelphia: Randall and Morse.)

What is the etiology of chalk deposits in the membrana tympani?

Deposits of chalk (Fig. 73) are usually the result of *long-continued inflammation* of the membrana tympani. Their presence does not indicate that the patient has the gouty diathesis. Only when large do they greatly interfere with the acuteness of hearing by stiffening the drum-head and interfering with its vibrations.

DISEASES OF THE MIDDLE EAR.

What is otitis media catarrhalis acuta?

Acute catarrhal inflammation of the middle ear is an acute inflammation of the mucous membrane of the tympanum, Eustachian tube, and, sometimes, of the mastoid cells, characterized by increased secretion of serum or mucus, but not of pus. Clinically, cases of acute catarrh of the middle ear are divided into two classes: one in which the attic of the tympanum and mastoid antrum are involved by the diseased process; and the other, in which the disease is confined to the Eustachian tube and atrium of the tympanum.

What other names are applied to the disease?

According to the character of the secretions the names applied are otitis media serosa acuta, otitis media mucosa acuta, and otitis media non-purulenta; according to the parts principally involved in the diseased process: otitis media catarrhalis ex tubæ, otitis media catarrhalis cum ostitide mastoidæ, acute Eustachian salpingitis, etc.

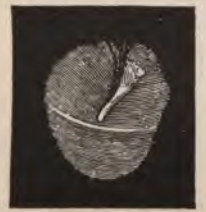
What is the etiology of acute catarrh of the middle ear?

The disease is in almost all instances the result of exposure to cold. Chronic catarrhal affections of the upper respiratory tract render many individuals susceptible to recurring attacks of inflammation of the middle ear, while in many instances carious teeth have the same effect. Very often the pain commences as a toothache, and later on the pain extends to the ear. In many cases the disease seems to be the direct result of surf-bathing or of diving into water from a considerable height.

What is the pathology of acute middle-ear catarrh?

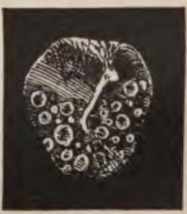
The affection in most cases begins as a catarrh of the pharyngeal orifices of the Eustachian tubes, accompanying similar disease of the nose and nasopharynx. If the pharyngeal orifice of the Eustachian tubes is inspected by means of the rhinoscope at the beginning of an attack, the mucous membrane of the tube mouths will be found so congested and swollen as to either completely close the tubes or at least greatly interfere with the proper ventilation of the middle ear. Later on the secretions from the tubes are abundant, becoming more consistent in most instances as the disease advances, so that a

FIG. 74.



Collection of Fluid Exudate in the lower part of the Tympanum, marked by a glistening line across the membrane. (From the right ear of a young man in the middle of an acute coryza.) Cure by Politzerization (Politzer).

FIG. 75.



Foamy Secretion in the Tympanum after Inflation, in a case of serous accumulation. From a patient with acute naso-pharyngeal catarrh (Politzer).

bulb of thick glue-like mucus may project from the orifices of the Eustachian tubes into the pharynx. The mucous follicles are sometimes swollen, giving a granular appearance to the tube-lips.

The appearance of the membrana tympani varies somewhat at the commencement of the disease. Generally it is pinkish in color, as the result of the congestion of the inner or mucous layer, and the manubrial plexus of blood-vessels is congested. Often the membrana is more dull and opaque than it is normally. Often a line, as fine as a hair, extending across the drum-head, indicates the upper level of the fluid within the tympanum (Fig. 74). If the fluid within the tympanum is thin and mobile, it will be seen to alter its position with the movements of the patient or during the use of the pneumatic speculum, when the upper level of the fluid often assumes a crescentic shape. By inflating the middle ear by the Politzer method the fluid can sometimes be broken into foam and the dim outlines of minute air-bubbles discerned through the drum-head (Fig. 75).

What is the prognosis?

The prognosis under appropriate treatment is favorable. Most cases completely recover. In neglected cases, however, the disease often assumes the purulent form or relapses into the chronic condition.

What are the symptoms?

Pain, increased by movements of the jaw, pressure over the tragus, or gently pulling the auricle outward. Hardness of hearing will be greater than in simple myringitis, if, indeed, myringitis ever occurs without the inflammation involving, to a certain extent, the entire mucous membrane of the middle ear. There will be present tinnitus and perhaps vertigo. The appearance of the membrane varies according to the amount of myringitis present. It may bulge outward at certain spots from the pressure of fluid within the tympanum, or the entire membrane may be flattened.

What is the treatment?

The pain is often relieved by the use of leeches. One large leech may be made to attach itself upon the skin between the mastoid and the jaw, as close underneath the auricle as possible, or two leeches may be placed just in front of the tragus. The artificial leech

(Fig. 54) may be used to advantage in the latter position. If the pain extends through the mastoid portion of the temporal bone, one or more leeches may be applied to this region. The use of leeches in the hyperæmic stage of acute otitis media when the pain is severe will not only relieve the pain, but will often also cut short the progress of the inflammation. After the use of leeches or the artificial leech hot applications should be made to the ear. This can be done by filling the auditory canal with hot water and afterward applying a hot flaxseed poultice over the auricle, which should be protected from direct contact with the flaxseed meal by means of a piece of thin linen spread over the surface of the poultice. The poultice should be renewed from time to time as it becomes cold should the continuance of pain require it. In many instances, however, pain is more quickly and completely relieved by the instillation of anodynes into the ear and the application of *dry heat.*

The patient may lie with the affected ear upon a hot-water bag or a bag of hot salt, and one or more drops of a 4 per cent. solution of cocaine be placed within the auditory canal from time to time. In some cases, however, a combination of morphia and atropia (Formula 28) seems to act better as an anodyne than cocaine. A hypodermic tablet of atropia and morphia may be dissolved in a few drops of warm water and be dropped into the ear. It is best to use a certain amount of caution in the use of powerful narcotic poisons within the auditory canal, as cases of poisoning have been reported. It is a safe rule never to drop into the auditory canal a larger amount of atropia or morphia than can safely be administered by the stomach.

When fluid is present within the tympanum an attempt should be made to evacuate it by the use of the Politzer air-douche. The nose and naso-pharynx should first be cleansed by the spray from an atomizer containing an alkaline solution (Formula 1 or 2) and a piece of absorbent cotton, saturated with a 4 per cent. solution of cocaine, inserted within each nasal chamber. After contraction of
binated bodies has been secured, the nasal chambers a
of the pharynx should be sprayed with a 4 per cent. s
pyrine to maintain the effects of the cocaine for se
relieve congestion of the pharyngeal lips of the
The Politzer air-bag should now be filled with the
chloroform, or *hot* air, and *used with no more forc*

to free the tube and middle ear from mucus. This treatment should be repeated once or twice a day, omitting the use of the cocaine and antipyrine if the naso-pharyngeal mucous membrane be not sufficiently swollen to require it.

If, notwithstanding antiphlogistic and other measures, there is bulging of the tympanic membrane, with indications that a perforation is likely to occur, it should be punctured by a paracentesis needle at the most prominent point of bulging or in the posterior inferior quadrant. The operation is not very frequently required, and should not be done unless it is impossible to free the ear from accumulations by the Politzer method.

In most cases of acute catarrh of the middle ear, if seen early, it is advisable to prescribe ⅓ of a grain of calomel combined with 5 grains of the bicarbonate of sodium, to be taken every hour for six hours, for the double purpose of securing free evacuation of the bowels and the alterative effects of the calomel, as it has been maintained that small, frequently-repeated doses of calomel have the power of controlling inflammation of mucous membranes.

What is otitis media catarrhalis subacuta?

The name is sometimes applied to that stage of catarrhal disease intermediate between the acute and chronic forms. By *subacute* catarrh of the middle ear, however, is generally meant an inflammation less severe in type than the acute. Pain is neither severe nor long continued, and the patient is deaf only for a short time. The attacks occur at frequent intervals. Upon examination the membrana tympani is found more pinkish in color than normal, and is decidedly opaque and lacks its usual lustre. The cone of light is either smaller than normal or has entirely disappeared.

What is the etiology?

The disease is commonest in children as the result of disease of the nose and pharynx, hypertrophied pharyngeal tonsil being an exceedingly common cause of the affection. Bad nutrition, carious teeth, and frequent attacks of coryza are common predisposing causes.

What is the treatment?

The treatment should be directed toward improving the patient's general health and removing any predisposing cause of the affection.

If the teeth are carious, they should receive the attention of a skilful dentist, while the efforts of the aurist should be carefully directed toward the removal of any morbid condition existing in the nose and naso-pharynx, because experience has amply demonstrated that in most cases attacks of subacute aural catarrh cease to recur as soon as a cure is brought about of the concomitant naso-pharyngeal disease. The knowledge of this fact, however, is not an excuse for neglecting local treatment of the ears while the nose and naso-pharynx are receiving attention.

Adenoid growths and hypertrophied faucial tonsils should be reduced in size, the former by means of Gottstein's curette, and the latter by the tonsillotome or by ignipuncture in the manner described in the "Essentials of Diseases of the Nose and Throat" of this series of compends.

At each bi-weekly or tri-weekly visit of the patient the nose and naso-pharynx should be cleansed by means of an atomizer filled with an alkaline antiseptic wash (Formula 1 or 2), after which the ears should be carefully inflated by means of Politzer's air-bag. If the inflammation of the middle ear is not too active, "massage" should be applied to the drum-head and the ossicles by the aid of Siegle's pneumatic speculum, after which there should be made to the interior of the nose and naso-pharynx an application of an iodine solution (Formula 11) in the case of children, or an astringent solution (Formulæ 12 and 13) in the case of adults, and the parts covered with albolene by means of the spray from an atomizer.

The hygienic surroundings of the patient should receive careful attention, and tonics and cod-liver oil should be prescribed in suitable cases. In children catarrhal inflammation is generally of an adenoid character; that is, the adenoid glands and the lymphatic elements of the mucous membrane bear the brunt of the disease, so that children and young adults do well upon iodine compounds applied locally and given internally. Syrup of the iodide of iron should be prescribed for internal use, either with or without cod-liver oil as the circumstances of the case seem to require, while hypertrophy of the lymphatic glands underneath the skin of the neck or mastoid should be treated by inunctions of compound iodine ointment (Formulæ 19, 20), repeated only often enough to produce a slight superficial redness of the integument.

Catarrh in adults is often characterized by inflammation of the mucous glands and interstitial elements of the mucous membrane; and it is in such cases that sedative applications and astringents are most useful. The vapors of various volatile substances are sometimes applied to the middle ear by means of Politzer's air-bag. The most useful of these substances are iodine, menthol, and chloroform. Glass-stoppered bottles, each partly filled with one of these drugs (Formulæ 22, 23, 24, 25), should be at hand in the aurist's office, so that the Politzer air-bag can readily be filled with the vapor of the drug which it is desired to use by inserting the nose-piece of the instrument within the neck of the bottle. The vapor can then be made to reach the mucous membrane of the middle ear by Politzer's method of inflating the middle ear or by the employment of an Eustachian catheter. The vapor of iodine, when thrown into the middle ear, acts as an alterative and gentle stimulant, that of menthol as a sedative, while chloroform vapor is probably simply a stimulant. It is generally easier to inflate the middle ear when the air-bag is filled with chloroform vapor than when it contains simply air.

What is otitis media catarrhalis chronica?

Chronic catarrh of the middle ear is a chronic non-suppurative inflammation of the mucous membrane and submucous tissues of the middle ear, producing deafness, tinnitus, and sometimes vertigo and other symptoms of altered auditory functions.

Into what forms may this disease be divided?

Two, the hypertrophic and the sclerotic, which are generally simply stages of the same disease.

What other names are sometimes applied to hypertrophic and sclerotic catarrh of the middle ear?

Moist and dry catarrh, hypertrophic and atrophic, catarrhal, and proliferous inflammation of the middle ear.

What is the pathology of chronic catarrh of the middle ear?

Gradual progressive changes take place in the mucous membrane and submucous tissues of the middle ear, similar in character to those that occur in the mucous membranes of other parts of the body, and analogous to cirrhosis of the liver, kidneys, or lungs and sclerosis of the brain and spinal cord.

The first stage of the disease seems to be a dilatation and engorgement of the capillaries, with an exudation of serum and round cells, both from the surface of the mucous membrane and also into its substance. The capillaries are engorged, the mucous membrane is swollen and œdematous; an exudate is constantly moistening its surface. The inflammatory exudate within the substance of the mucous membrane itself contains large numbers of round cells, which proliferate and also increase in size by a process of elongation, so that they are finally converted into newly-formed connective tissue, sometimes causing cords, bands, and membranes similar in appearance to cicatricial tissue following suppuration.

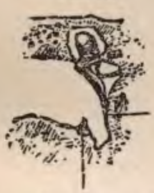
During the earlier stages of the disease the thickened mucous membrane is redder and rougher than normal, soft and easily depressed with the end of a probe. As a result, however, of the gradual increase of connective tissue and the absorption of the more fluid parts of the exudate, the mucous membrane, while still much thicker than normal, is pale and quite smooth. This condition represents a stage intermediate between hypertrophy and atrophy of the tympanic mucous membrane.

As a mechanical result of the ultimate contraction of the newly-formed connective tissue, the glandular elements of the mucous membrane disappear, and it finally resembles more and more closely "scar-tissue." The mucous membrane becomes smooth, thin, and secretes but little fluid. In some cases atrophy or sclerosis of the mucous membrane of the tympanum rapidly occurs without any pre-existing stage of hypertrophy. Such cases are often the result of syphilis, or they follow purulent inflammation of the mucous membrane with or without perforation of the drum-head.

It should not be supposed that the changes in structure above described progress evenly throughout the entire mucous membrane. Often depressed, scar-like spots of atrophy are seen in the midst of the rough, succulent, and swollen mucous membrane characteristic of the hypertrophic stage of chronic aural catarrh.

Not only are the mucous and submucous structures involved in long-continued catarrh of the middle ear, but the bony structures are affected as well, and, ultimately, the labyrinth also. The cavity of the tympanum generally becomes more roomy, and as a result of interference with the nutrition of the parts chalk deposits take place in the deeper layers of the mucous membrane close to the bone, in the membrana tympani, the membrane of the round and oval windows, and in the ligaments and cartilages connected with the ossicles. The ossicles frequently become ankylosed, and adhesions form which bind them to one another or to the surrounding bony walls of the tympanum, while bands of newly-formed connective tissue may extend across the tympanum or mastoid antrum. The membrana tympani and manubrium sometimes become adherent to the promontory (Fig. 76).

FIG. 76.



Schematic Section of a Case of Attachment of the Manubrium to the Promontory (Politzer).

Ordinarily, catarrh of the middle ear is but part of a diseased process involving the nose, throat, Eustachian tubes, and mastoid cells. The stage of the disease and the degree of inflammation may vary in the different parts affected. In many instances the Eustachian tube is the first part of the middle ear affected, Seiss claiming that chronic Eustachian salpingitis "is the most frequent ear disease occurring in the Eastern United States."[1] In some instances the disease progresses by continuity of structure from the pharyngeal mouths of the Eustachian tube into the tympanum; while in others stenosis of the tube, from swelling of the lining mucous membrane or accumulation of secretions, interferes with the proper ventilation of the tympanum, thus producing a partial vacuum within the cavity, a constant "dry-cupping," as it were, of the tympanic mucous membrane, with consequent engorgement of its capillaries.

What is the etiology of otitis media catarrhalis chronica?

It is generally the result of an extension of a similar disease of the naso-pharynx through the Eustachian tubes. The chronic condition may become established after repeated attacks of acute catarrhal inflammation of the middle ear. Carious teeth seem to cause chronic catarrh of the middle ear, probably as the result of reflex irritation. Syphilis sometimes causes chronic catarrh of the middle ear, but more often suppuration occurs as the result of diphtheria, measles, scarlatina, or typhoid fever. Those constantly exposed to loud noises as the result of working at certain trades, like boiler-making, are especially prone to lose their hearing from chronic catarrh of the middle ear. Syphilis, scrofula, and any condition of lowered vitality, inherited or acquired, may be enumerated as predisposing causes of the disease.

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[1] *System of Diseases of the Ear, Nose, and Throat*, edited by Charles H. Burnett, vol. i. p. 658.

What are the subjective symptoms of otitis media catarrhalis chronica?

Gradually increasing deafness. The decrease in the power of hearing is, however, by no means uniform. Successive attacks of subacute exacerbations of the catarrhal inflammation produce comparatively great impairment of the hearing-power, which in turn somewhat improves. In this manner the disease progresses, the hearing being better or worse from week to week, but becoming more or less impaired from year to year. Many patients hear better during clear, dry weather than on rainy or damp days. The acuteness of hearing may not decrease to the same degree for all sounds. Many patients hear a watch tick at almost the normal distance, but hear spoken words very indistinctly. A common remark from such patients is that they hear the sound of the voice distinctly, but are unable to distinguish the words spoken. In other cases the impairment of hearing is most manifest for musical tones, like those emitted by a tuning-fork.

A sense of fulness and discomfort within the ear, sometimes pain, and certain modifications of the hearing are not uncommon during the course of chronic aural catarrh, the commonest modification of the hearing-power being *paracusis Willisii*, or increased hearing-power in the midst of noise, as, for example, when the patient is on a moving railroad train. This phenomenon has been ascribed to great rigidity of the ossicles and contraction of the tensor tympani muscle, and it is claimed to be of somewhat sinister import as to the ultimate effects of treatment.

Disacousma, or *dysæsthesia acoustica*, is a condition in which loud noises, or even those of moderate intensity, cause painful sensations. When the patient hears his own voice, somewhat altered in character and pitch, as if it came from a distance or through the tissues of his head, the symptom is called "*autophony*." *Paracusis duplicata* and *paracusis diplocusis* are names given to the phenomenon in which the patient hears sounds as if repeated twice, the second sound seeming somewhat like an echo of the first. Probably in most cases of chronic catarrhal deafness sounds are not only altered in intensity, but also in pitch and character as well. It is difficult, however, to observe any subjective alteration in the character or pitch of musical notes, except in the case of musicians who are deaf only in one ear. In such cases not unfrequently the note of a tuning-fork will seem to be of a different character and pitch when sounded before the deaf ear from that emitted by the same fork when sounded before the patient's normal ear. When subjective alteration of the character and pitch of sounds is sufficiently manifest to be a source of discomfort to the patient, the name *pseudacousma*, or false hearing, is applied.

Tinnitus, subjective ringing or hissing sounds heard in the ear, is a symptom of aural catarrh rivalling in importance even progressive hardness of hearing. It is sometimes the only symptom of which the patient complains, the fact being that, although he is somewhat deaf, yet his hearing is still sufficiently acute for the ordinary purposes of his life and occasions no discomfort whatever. Such patients are, some of them, actually surprised when tests of their hearing demonstrate that it is defective. This is especially the case when only one ear is diseased. Tinnitus is usually worse at night, and it may not be present at all in some cases during the daytime. It is subject to great variations in degree in some cases of aural catarrh, disappearing for months at a time and then reappearing. Usually tinnitus becomes more annoying as the disease progresses. Involvement of the labyrinth may increase or decrease tinnitus according as the nerve-fibres are simply irritated or are destroyed.

Vertigo is commonly a symptom of chronic otitis media, usually transitory in character. In all cases it is probable that aural vertigo is due to some condition within the semicircular canals of the labyrinth: generally it is simply an alteration of the normal interlabyrinthine pressure produced by increased tension exerted through the fenestræ by fluid within the tympanum, or by a contracted tensor tympani through a rigid chain of ankylosed ossicles. Only when *structural changes* have occurred to the tissues within the labyrinth should the name "Ménière's disease" be given to a condition which otherwise is simply aural vertigo and one of the symptoms of disease of the middle ear.

What are the objective symptoms of otitis media catarrhalis chronica?

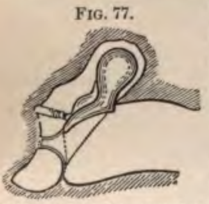
The most important objective symptoms are those revealed by inspection of the membrana tympani, ascertaining the condition of the Eustachian tubes, and testing the hearing by means of the voice, the watch, and tuning-forks.

Although the condition of the membrane is not invariably an index of the condition of the tympanum, yet certain inferences may be drawn from its appearance that are all the more valuable because it is the only visible part of the tympanum. The lustre and color of the drum-head may be nearly normal both at the commencement of chronic otitis media and also at a stage of the disease when the atrophic changes are not far advanced. In the latter condition, however, the membrane is generally abnormally translucent, so that a red reflex from the promontory is discernible, and also the outlines of the descending process of the incus, the incudo-stapedial articulation, and, sometimes, the crura of the stapes. During the hypertrophic period of catarrh of the middle ear evidences of involvement of the drum-head are usually not lacking. There may be patches of opacity, or the whole drum-head may have lost its translucency and appear white, rough, thick, and opaque. The light spot may not occupy its normal position as the result of an indrawing of the drum-head, or it may be smaller than normal because of a roughening of its surface, and from the same cause or from local depressions it may divide into two or more maculæ. If the drum-head is greatly depressed, a light spot sometimes appears over the short process, which projects outward through the tightly-drawn tissues like the knuckle of a finger. The handle of the malleus is, under such circumstances, "foreshortened," appears shorter than normal, or it may be drawn so far backward as to lie almost horizontal beneath the posterior fold. Spaces abnormally white and opaque may be interspersed upon the same membrane with spots abnormally thin and translucent.

It is always a matter of considerable importance to determine the resiliency and tension of the membrane. This may be effected by observing the movements of the drum through Siegle's pneumatic speculum (Fig. 35) during rarefaction and compre [illegible] within the auditory canal. When the air within th [illegible] by means of this instrument, a drum-head se [illegible] rests upon the promontory may be sucked outward until it appears like a balloon, a groove upon its convex surface indicating the position of the malleus handle. Sometimes isolated areas upon the drum-head will exhibit abnormal mobility. Ordinarily such spots are cicatrices formed by the closure of a perforation. This appearance may be produced, however, by localized atrophy.

Deep localized depressions are found at spots where adhesions have occurred between the membrane and promontory (Fig. 77), such spots appearing much darker than the surrounding area. Sharply-defined deposits of chalk, more especially in the posterior half of the drum-head, are not uncommonly seen (Fig. 73).

FIG. 77.



Diagrammatic Section of a Small Depressed Cicatrix attached to the Promontory (Randall).

The patency of the Eustachian tube is tested by the Politzer method of inflation. During the earlier stages of the disease the tubes are usually somewhat obstructed, but during the later stage they are abnormally patulous. A favorable prognosis may be given the patient if after inflation of the tympanum the hearing is greatly improved. Under-such circumstances the impairment of hearing is largely due to obstruction of the Eustachian tubes—a condition amenable to treatment. If, however, the tympanum is easily inflated by the Politzer method, and there results considerable outward movement of the membrana tympani without much improvement in the hearing, the prospect of speedily improving the acuteness of hearing without operative interference is not encouraging.

In the hyperæmic and hypertrophic stages of catarrhal deafness hearing for the voice is usually proportionately better than for the watch and tuning-fork; in the atrophic form of the disease, however, the reverse is usually the case. If only one ear be affected, a vibrating tuning-fork placed on the vertex, forehead, or teeth (Weber's method) is heard best in the affected ear so long as the functions of the auditory nerve and labyrinth are unimpaired. When, however, serious involvement of the labyrinth has occurred, tissue-conduction, as tested by Weber's method, will be found greatly diminished or even abrogated upon the affected side. Before involvement of the receptive apparatus has occurred a vibrating tuning-fork with its handle upon the mastoid will be heard better than when its vibrating tines are held in front of the ear (Rinne negative). Rinne's test is positive when the labyrinth is seriously involved, and under such circumstances hearing both by tissue and aërial conduction is more greatly impaired for the higher notes of the musical scale than for the lower notes.

What is the prognosis?

The prognosis is only favorable in cases in which the disease has not progressed beyond the early hypertrophic stage of the disease. Fluid exudates will be absorbed as the result of treatment, and simple inflammation of the mucous membrane of the tympanum will disappear. The prognosis is all the more favorable if the disease is the result of pathological conditions within the nose or nasopharynx, because in such cases, when the nose and throat are restored to a nearly normal condition, chronic aural catarrh of recent origin usually subsides as the result of appropriate local treatment. The progress of the disease can, in most instances, be delayed, but when new connective tissue has formed it remains, and atrophied parts cannot be regenerated. The prognosis is generally hopeless, so far as improvement of the hearing is concerned, in cases in which the labyrinth is seriously involved.

What is the treatment?

An effort should be made to improve the hygienic surroundings of the patient, and to so improve his general health as to render him less liable to contract colds. The nose and throat should, if necessary, receive appropriate treatment. Hypertrophies, ecchondroses, and exostoses of the nasal chambers and adenoid vegetations in the pharyngeal vault should be removed; hypertrophied faucial tonsils should be reduced to their normal dimensions by means of the galvano-cautery.

Tri-weekly, or even daily, inflation of the Eustachian tubes is of great importance. For this purpose Politzer's method should be employed, when possible, in hypertrophic cases. In atrophic cases, however, the irritation produced by the introduction of the Eustachian catheter is sometimes of marked benefit. Either simple air or air saturated with the vapor of chloroform, iodine, or menthol [illegible] used for producing the inflation (Formulæ 22, 23, 24, 25).

In cases where the labyrinth is involved Politzer's method of inflation should be used with extreme gentleness if at all. Ordinarily the Eustachian tubes instead of being contracted are widely dilated, and the violent use of Politzer's bag causes a most unpleasant sensation to the patient and an immediate decrease in the hearing power, which gradually grows worse from repetition of the treatment.

Many cases of atrophy not too far advanced are greatly benefited by a spray of menthol in fluid alboline (Formula 7) thrown into the middle ear by means of the Eustachian catheter and atomizer. After introducing the catheter and applying the auscultation tube, the patulency of the Eustachian tube is tested by means of Politzer's bag (Fig. 49) and the nozzle of atomizer inserted within the proximal extremity of the catheter. In cases where the Eustachian tube is widely dilated the spray from the atomizer will be heard to enter the tympanum; but in most instances it enters the Eustachian tube for but a short distance except during the act of swallowing by the patient. After a time a certain amount of oil condenses in the catheter and Eustachian tube. This should be blown as far up the tube as possible by means of Politzer's bag.

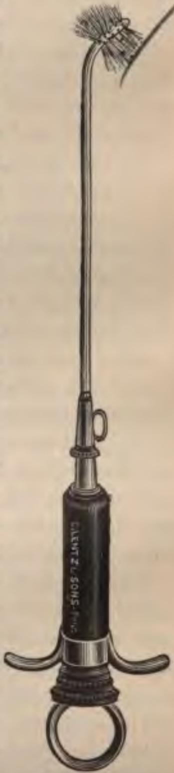
It is convenient to use an air receiver to work the atomizer in order to secure steadiness of its tip when inserted into the catheter, but with a little care an ordinary hand atomizer may be employed without inconvenience to the patient. It is doubtful if a large amount of the oil actually enters the tympanum in the majority of instances, and an excessive quantity if present would be removed when Politzerization is employed after the use of the atomizer, and hence the method is entirely free from danger. When the Eustachian tube is contracted, the oil seems in some instances to act almost like a Eustachian bougie and secures dilatation.

The injection of watery solutions into the middle ear has nearly been abandoned; but in cases of chronic catarrhal Eustachian salpingitis injections of weak alkaline solutions (Formula 1 or 2) into the pharyngeal mouths of the Eustachian tubes by means of Seiss's catheter syringe (Fig. 78) may be useful for the removal of masses of glue-like mucus. Strictures of the tubes may be dilated by carefully passing a Eustachian bougie through the stricture, but the use of this instrument requires the utmost care to avoid a disastrous, or even fatal, result from emphysema as the result of tearing the tubal mucous membrane.

Next in importance to inflation of the middle ear is systematic massage by means of Siegle's pneumatic speculum (Fig. 35), by means of which the air within the auditory canal can alternately be rapidly condensed and rarefied, and motion be thus imparted to the membrana tympani and ossicles. This procedure is almost invariably followed by an amelioration of tinnitus if this symptom be present, and it probably constitutes the most satisfactory treatment for this annoying symptom, although freezing the tissues over the mastoid process by means of the spray from an atomizer containing ether, and exhausting the air within the auditory canal by a plug of oiled absorbent cotton, sometimes yield good results.

Systematic massage of the middle ear by means of the patient's finger tips is of the greatest value, for whilst it is somewhat dangerous to instruct an individual to inflate his middle ears by Valsalva's method, as its frequent use is liable to be followed by atrophy of the drum-head and increased deafness, auto-massage with the finger tips is entirely harmless, and may be used for the relief of tinnitus whenever it becomes annoying. The forefinger should be slightly moistened and slipped into the meatus with the nail toward the tragus. With rapid piston-like movements of the finger tip inward and outward a patient can easily exercise alternations of pressure and rarefaction of the air within the auditory canal, and hence massage the intra-tympanum almost as thoroughly as if a pneumatic speculum were used. He may be instructed to employ the method several times a day with increasing relief to the ear of tinnitus in many instances, and generally improvement of the acuteness of hearing. It is seldom that the method fails to afford a temporary relief from the feeling of fulness or pressure with

FIG. 78.



Seiss's Syringe Catheter.

Phono-massage, by means of sounds conveyed to the ear through rubber tubes from various musical instruments or similar contrivances, has been employed in the treatment of catarrhal deafness and tinnitus. If the ears of an individual with catarrhal deafness be subjected for a length of time to musical tones of about the same pitch as the tinnitus from which he suffers, the subjective noises will either entirely disappear or be greatly alleviated, probably as the result of fatigue of the portion of the internal ear adapted for the perception of sounds of that pitch. This method of treatment, which recently was used somewhat extensively, has been largely abandoned in favor of more rational methods. It has little to recommend it.

Pneumo-massage with electro-magnetic and other machines capable of producing rapid alternate rarefaction and condensation of the air in the auditory canal is undoubtedly of benefit in a large propor- of chronic middle-ear catarrhs, but is probably in no way superior to massage with the pneumatic speculum or the tip of the forefinger of the patient or surgeon as described above. The same remark also applies to direct massage of the chain of ossicles by means of a spring probe the cup-shaped end of which fits over the short process of the malleus to prevent slipping; and also to the so-called "internal massage," where short, sharp puffs of compressed air from an air-receiver are, by means of an "automatic cut-off" rapidly worked with the tip of the thumb, thrown through a catheter into the Eustachian tube. Between the automatic cut-off and the catheter may be placed an atomizer, a nebulizer, or any other instrument capable of medicating the compressed air employed.

The wedging of a little ball of absorbent cotton into the space above the short process of the malleus, where its weight and pressure serve to constantly push outward the malleus-handle and the long process of the incus, thus diminishing pressure on the stapes, in a certain number of cases will afford efficient aid in the treatment of tinnitus and hardness of hearing. The little mass of cotton should be moistened with a suitable antiseptic solution, so that it can be moulded to the parts when inserted above the malleus-handle, and may with benefit in certain cases be worn for several weeks at a time. It is not readily dislodged from its position by massage either with the pneumatic speculum or the finger-tip, and sometimes gives immediate and ultimately permanent relief from tinnitus.

Tension of the transmitting apparatus of the middle ear may also be decreased by operative procedures, such as repeated paracenteses of the drum-head, tenotomy of the tensor tympani and stapedius, or removal of the membrana tympani and one or more of the ossicles.

The head noises complained of by patients are almost as numerous as the individuals affected, but may be divided into three classes —the pulsating, the continuous, and sounds more or less elaborated, like the ringing of bells, music, and words and sentences uttered with more or less distinctness, the latter class only being referred to a point outside the head.

Tinnitus is more often pulsating than patients are willing to admit until the fact is demonstrated to them by placing the hand upon their pulse and beating time to it with a finger. Sometimes the result of anæmia, or more rarely of an aneurism, pulsating tinnitus ordinarily indicates arterial congestion of the middle ear or of the labyrinth. The differential diagnosis between the two conditions can be made with a limited amount of accuracy by pressure upon the carotids or on the vertebral arteries at the point where they cross the atlas, because a branch of the carotid supplies the tympanum, and a branch of the vertebral supplies the labyrinth.

The faint pulsating tinnitus due to anæmia is diminished by the patient's lying down, and in many instances can be permanently cured by hygenic measures and suitable tonics, among which the well-known pil. sumbul comp. is especially useful. Pulsating tinnitus due to congestion, on the other hand, may be alleviated by the bromides, of which, for a reason that will appear below, dilute hydrobromic acid, in doses of from 15 to 60 drops three times a day, is probably the best.

The earlier stage of chronic catarrh of the middle ear is ordinarily accompanied by tinnitus, generally constant in character. Later on, as deafness becomes profound, tinnitus often disappears, probably as the result of diminished sensibility of the internal ear. Tinnitus due to middle-ear catarrh is sometimes alleviated by large doses of the bromides; but better results can be obtained in a limited number of cases by the patient taking after meals, for a few weeks, a pill containing $\frac{1}{4}$ grain of nitrate of silver, $\frac{1}{3}$ grain of extract of hyoscyamus, and $\frac{1}{30}$ grain of strychnia.

Inflammation of the external auditory canal, foreign bodies, impacted cerumen, and polypus are capable of producing tinnitus, and in rare cases vertigo, nausea, cough, or even epileptiform convulsions.

Not always is tinnitus the result of diseases of the ear, but rather is a reflex phenomenon due to the irritation of some correlated region—the nose, teeth, or more frequently the digestive tract. Just as acute dyspepsia is ordinarily accompanied by vertigo, so the more chronic ailments of the digestive tract sometimes occasion a tinnitus the cause of which is little suspected. The manner in which disease of the digestive tract, teeth, or nose produces tinnitus is, as pointed out by Woakes, through the nervous connection, more or less direct, of these organs with the inferior cervical sympathetic ganglion, which supplies the nervi vasorum to the occipital artery and its branch, the internal auricular. Irritation of the inferior cervical sympathetic ganglion would cause tinnitus as the result of dilation of the arterioles of the cochlea, which, at first pulsating, would afterward become constant in character as the result of trophic changes resulting from increased blood-supply. Quinine, the salicylates, and certain other drugs are capable of producing tinnitus, either as the result of aural hyperæmia or by their toxic action upon the internal ear. There is also reason to suppose that in lithæmia the products of indigestion exert a similar action in the production of tinnitus. It is therefore in cases where dyspepsia and lithæmia have done their share in the production of tinnitus that acids, including hydrobromic acid, are especially useful in controlling this annoying symptom. Five-drop doses of concentrated nitro-muriatic acid in a glass of water after meals sometimes afford speedy relief from head-noises by freeing the blood of uric acid. Proper regulation of the diet, regular exercise in the open air and sunlight, as by bicycle-riding, will, in cases where there is neither disease of the ear, nose, or teeth to account for tinnitus, generally result in a disappearance of the head-noises.

The more elaborated subjective sounds, heard as if produced outside the body—such as the ringing of bells and spoken sentences—are the result of disease of the ear acting on an easily excitable brain. Some of the cases are at least on the border-line of insanity, and not only hear voices but see visions, either religious or otherwise in character. Benefit sometimes results from treating the concomitant aural disease.

What is otitis media suppurativa acuta?

Acute purulent inflammation of the middle ear is, as its name implies, an acute purulent inflammation of the mucous membrane of the tympanum, and usually also of that of the Eustachian tube and mastoid cells.

What is the pathology?

The tympanic mucous membrane is of a bright-red color, much swollen and devoid of its epithelium. There is cellular and serous infiltration of its connective-tissue layer, and much exudation of muco-pus or pus from its surface. Perforation of the membrana tympani occurs in the majority of cases, the pus being then discharged through the perforation into the auditory meatus; occasionally the discharge is tinged with blood.

What is the etiology?

Generally the disease is the result of a cold or of traumatism, or it may occur as a complication during diphtheria, scarlatina, smallpox, measles, and typhoid fever. Not unfrequently the disease is caused by syphilis or tuberculosis. Purulent inflammation of the middle ear is very common in children. Carious teeth and nasopharyngeal disease are predisposing causes of the affection.

What are the symptoms?

An attack is ushered in by pain in the ear, shooting over the side of the head. Sometimes the pain originates in a diseased tooth and extends to the ear. Chilly sensations and fever are sometimes present, the temperature reaching as high as 102° or 103° F. The ear feels full, and there are tinnitus and deafness, the pressure of confined pus upon the secondary membrane sometimes interfering with the functions of the labyrinth. When perforation takes place there occurs a rapid alleviation of the pain, tinnitus, and deafness.

The appearance of the drum-head is that of acute myringitis. At the end of a few hours to several days, or even weeks, from the beginning of the attack, a bulging at some point upon the drum-head indicates the position where the pus will burrow its way through the membrana. When, however, the attic and mastoid antrum contain pus which, because of swelling of the mucous membrane about the ossicles, cannot readily drain into the atrium of the tympanum, this pus will sometimes burrow underneath the skin of the auditory canal, and find an exit either at some point within the canal or behind the auricle. Those cases in which no perforation occurs run a tedious course, and some permanent impairment of the hearing usually ensues. The duration of the disease from the occurrence of a perforation to its closure is very variable. In cases where the perforation occurs early it may remain open only for a few days. Three or four weeks are ordinarily required for the closure of a small perforation.

If the perforation is large, it will probably remain open long after suppuration has ceased, to finally close by cicatricial material destitute of all fibres of the membrana propria, and will bulge inward and outward with the varying intertympanic pressure.

Extensive destruction of the structures of the middle ear sometimes occurs during acute otitis media. This is especially apt to take place when the disease appears as a complication of scarlatina, variola, or diphtheria. The whole of the drum-membrane and all of the ossicles may come away within a few days from the onset of the middle-ear disease as an enormous slough. In other cases ulceration, starting from the perforation, proceeds more slowly, but it accomplishes equally disastrous results. Inflammation of the mastoid is occasionally a serious complication of acute otitis media, and the labyrinth sometimes participates in the purulent inflammation of the tympanic cavity, the ultimate result in such cases being usually brain-abscess and death.

What is the prognosis?

The prognosis of acute purulent inflammation of the middle ear, when it occurs in an otherwise healthy individual, is usually favorable. The disease, however, frequently assumes the chronic form, and in tuberculous individuals this is the usual outcome of the affection.

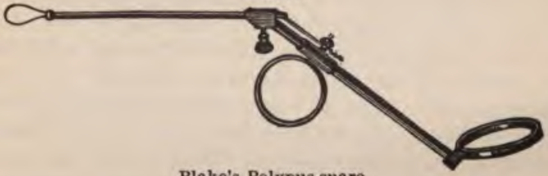
What is the treatment?

In the early stages of the disease leeches, hot applications, and the other measures for the relief of pain already specified are useful for the relief of pain in catarrhal inflammation of the middle ear. Paracentesis of the membrane should be done as soon as bulging occurs. The cut should be 2 or 3 millimetres long, and should be made with a paracentesis needle through the point at which the bulging occurs or in the posterior quadrant of the membrana tympani. When there is considerable swelling of the upper posterior part of the auditory canal, indicating the presence of pus beneath the skin of this region, the thrust should be through Shrapnell's membrane, and the needle be so withdrawn that its point will cut through the swollen tissues at the upper posterior portion of the canal to the bone, in order to secure free drainage.

After incision of the drum-membrane, or when rupture has occurred spontaneously, the major part of the pus within the auditory canal should daily be removed by means of absorbent cotton wrapped about the end of a probe, and the pus within the tympanum expelled through the opening in the drum-head by the Politzer method of inflation. After this has been accomplished the auditory canal should be cleansed thoroughly by means of a cotton-tipped probe wet with a 15-volume solution of peroxide of hydrogen, and the parts thoroughly dried, and covered with powdered boracic acid by means of the powder-blower.

If exuberant granulations sufficiently large to obstruct free drainage from the tympanum occur, they should be removed by means of a snare (Fig. 79), by forceps, or by touching them with nitrate of

FIG. 79.



Blake's Polypus-snare.

silver or chromic acid fused on the end of a probe. Considerable caution is required in the use of chromic acid. The granulations or small polypi should first be dried thoroughly by means of absorbent cotton, in order to prevent the acid dissolving and flowing over adjacent structures. No more of the acid should be applied than is necessary to accomplish the desired result, and any excess remaining within the canal should be neutralized by syringing with a wa alkaline solution. Small polypi and exuberant granulations are n apt to occur, and obstruct drainage when the pus has found its through an opening in Shrapnell's membrane or at a point on the upper and posterior part of the auditory canal.

What is the etiology of otitis media suppurativa chronica?

Chronic purulent inflammation of the middle ear is generally caused by neglect or improper treatment of acute purulent disease of the middle ear. The affection may, however, develop primarily as the result of syphilis or tuberculosis.

What are the symptoms?

There is a muco-purulent or purulent discharge, sometimes tinged with blood. The acuteness of hearing varies according to the amount of destruction of the structures of the middle ear that has occurred or to the presence of polypi or semi-inspissated secretions blocking the canal or interfering with the functions of the ossicles. In some instances the hearing is nearly normal, whilst in others deafness is nearly absolute. Tinnitus may or may not be present.

The presence of a discharge in the auditory canal from the middle ear presupposes the presence of a perforation of the drum-head. The perforation, on the one hand, may be so minute as to escape observation by otoscopy, its presence being only revealed by a "perforation whistle" during inflation of the ear either by Politzer's or Valsalva's method. On the other hand, the destruction of the drum-head may be so extensive as to expose the cavity of the tympanum to view and reveal all of the structures of the inner wall. In some cases, indeed, the remains of the drum-head may be represented only by a narrow ring; in other cases the ossicles may have also disappeared, either from ulceration and sloughing of their ligaments or by necrosis of the bones themselves. Necrosis of some portions of the tympanic walls may also exist. The appearance of the tympanic mucous membrane varies somewhat. In one class of cases it is simply red and swollen, while in another class it appears granular, and polypi may be present, perhaps covering the orifice of a sinus leading to exposed bone.

Mastoid abscess, thrombosis of the sinuses of the dura mater, pyæmia, meningitis, brain-abscess, and death may result from chronic purulent inflammation of the middle ear, and the purulent process may also attack the structures within the labyrinth.

What is the treatment?

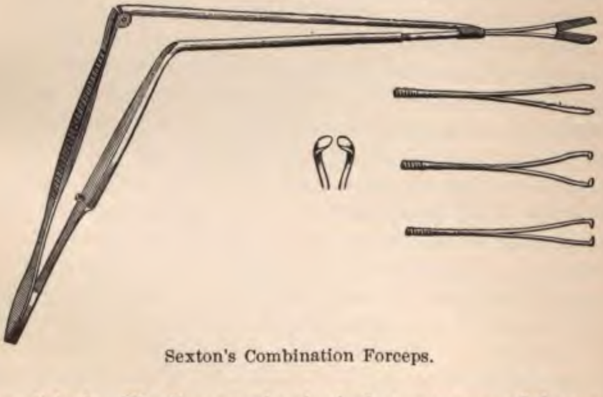
The treatment of uncomplicated cases consists in daily thorough cleansing of the interior of the drum, already described as necessary in the treatment of acute purulent inflammation of the middle ear. If the perforation through the membrana is not sufficiently large to permit of this being readily accomplished, it should be enlarged or a counter-opening made, and the interior of the drum syringed with peroxide of hydrogen by means of Blake's middle-ear canula (Fig. 54). When, with a large perforation, pus is seen to flow downward from the attic or the tympanum, the nozzle of the curved canula should be introduced into the attic through the perforation, and a small amount of the peroxide injected toward the tegmen tympani.

After the cavity has been thoroughly cleansed it should carefully be dried by means of absorbent cotton wrapped about a probe, and the parts covered by powdered boracic acid. The success of the treatment depends upon the thoroughness with which the cleansing is accomplished at each daily visit of the patient.

If the tympanic mucous membrane is granular, the routine treatment outlined above will not be sufficient to secure a speedy cessation of the discharge until the granulations are destroyed. Alcohol has the power to cause a shrinking of the granulations, and absolute alcohol may be applied by means of a cotton-tipped probe at each daily visit of the patient after the ear has been thoroughly cleansed. The application of absolute alcohol causes some pain, and it may augment the discharge for a few days: 50 to 95 per cent. alcohol may also be prescribed for the patient's use at home, a few drops being instilled into the ear several times a day, care being exercised that the patient's head is held in such a position each time that the alcohol dropped into the ear will be sure to reach the cavity of the tympanum. An application of a solution of the nitrate of silver, 60 grains to the ounce of water, applied by means of a cotton-tipped probe once or twice a week, generally secures a speedy shrinking of the granulations. After the application of either absolute alcohol or a 60-grain solution of nitrate of silver the tympanic mucous membrane should be covered with powdered boracic acid.

When the granulations are isolated they may be scraped away with a sharp curette or be removed with the forceps. Large granulations and polypi are best removed with a snare. It should be borne mind, when removing a polypus with a snare, that, although the polypus is absolutely devoid of sensation, the wall of the auditory canal, as the result of long maceration in pus, is often exquisitely sensitive, and in guiding the wire loop of the snare over the polypus it is advisable to avoid, as far as possible, touching the auditory canal. Watery solutions of cocaine, not being readily absorbed through the skin of the canal, are of but little value in preventing pain during the operation, but they may be employed as a *placebo* to remove the nervous apprehensions of the patient. Indeed, if the operator be reasonably skilful and he avoids touching the auditory canal as far as possible, the pain of the operation is not usually great. If the polypus is large, an effort should be made to locate its pedicle by means of a probe. The wire loop of the snare should then be worked gradually inward over its surface until, if possible, the pedicle of the polypus is encircled. The wire loop should then be tightened and made to cut through the polypus. If the operator has not succeeded at the first attempt in removing the whole of the polypus, this manœuvre may be repeated until the desired result has been accomplished. Bleeding may be checked at any stage of the operation by means of a tampon of absorbent cotton, and by afterward cauterizing the stump of the polypus with nitrate of silver fused on the end of a probe.

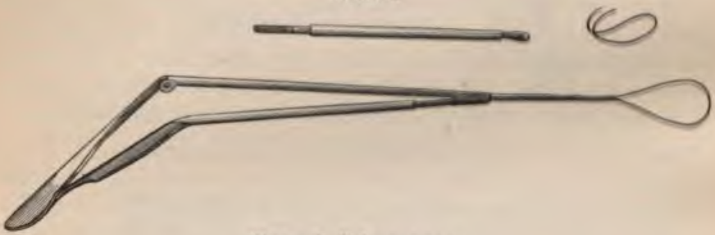
FIG. 80.



Sexton's Combination Forceps.

For the removal of polypi Blake's snare (Fig. 79) is perhaps the most convenient instrument, but Sexton's, Gruber's, or Wild's snare is almost equally efficient. Recently the author has had made an aural polypus-snare consisting of a needle and canula, so constructed as to be used as an auxiliary "tip" with Sexton's combination forceps, so that when the eye of the needle is threaded with wire the loop so formed can be enlarged or diminished at the pleasure of the operator—a matter of some importance in guiding it along the auditory canal over a large polypus. Other advantages of this instrument are the quickness and ease with which it can be manipulated, and the fact that when the wire is in position around a small polypus the *canula* can be thrust forward over the wire loop, and thus prevent the wire slipping over the polypus instead of excising it (Fig. 81).

FIG. 81.



Gleason's Polypus-snare.

What is the pathology of aural polypi?

Aural polypi may be divided into four classes. About 50 per cent. of all aural polypi are granulation-tumors, having the same structure as ordinary granulations, but covered by either squamous or columnar epithelium; 90 per cent. of aural polypi, other than granulation-tumors, are mucous papillomata. They are extremely vascular, and sometimes bleed at the slightest touch. Their structure consists of capillary loops surrounded by a stroma of somewhat imperfectly-developed connective tissue containing cuboidal epithelial cells. They are covered by a pavement epithelial layer of varying thickness. Fibroid polypi (fibromata), which are somewhat rare, are usually found as large, dense, pale polypi developed from the peri-

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osteal or deeper layer of the tympanic mucous membrane. Fibrous polypi are also covered by several layers of pavement epithelium. Myxomatous polypi are very rarely found in the human ear. Aural polypi are not malignant, the treatment outlined above being sufficient to prevent a recurrence of the growth. It should be borne in mind, however, that epitheliomata, sarcomata, and gummata are said to sometimes occur in the middle ear and to present the appearance of polypi. Such growths are, indeed, very rare in this situation.

What are the symptoms of aural polypus?

Long-continued discharge, sometimes streaked with blood, is usually the only subjective symptom. Certain reflex symptoms, the result of peripheral irritation caused by the presence of an aural polypus, have been described as occurring in rare cases.

Most aural polypi have their origin at the posterior and upper part of the tympanum. They may, however, arise from any part of the tympanic cavity, or even from the dermic layer of the drumhead. Sometimes they originate at the mouth of a sinus extending through the skin of the auditory canal to carious or necrosed bone.

What is the etiology of aural caries and necrosis?

Caries or necrosis of the temporal bone may occur during the course of long-continued suppuration of the middle ear or as the result of syphilis or tuberculosis. The upper and posterior part of the auditory canal and the mastoid are the portions most usually first attacked.

What are the symptoms and course of the disease?

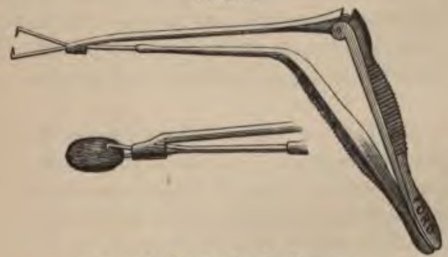
Circumscribed caries may exist within the tympanum during chronic purulent disease of the middle ear, and present no symptoms other than that exposed and roughened bone can be detected by means of a probe. Sudden paralysis of the facial nerve may occur as the result of necrosis of the inner wall of the tympanum involving the facial canal; however, a considerable portion of the facial canal may be opened and the nerve be bathed in pus for some time before symptoms of Bell's palsy occur. The labyrinth may be opened, generally through the horizontal semicircular canal, and brain-abscess occur. The tegmen tympani and tegmen mastoidi not unfrequently are destroyed as the result of necrosis or caries. Under such circumstances there commonly occurs a local pachymeningitis, which prevents the spreading of the disease upon the dura mater.

If caries or necrosis attacks the mastoid antrum or the anterior portion of the mastoid cells, there are pain, swelling, and infiltration of the skin at the posterior inner portions of the meatus. At first hard, the swelling becomes soft and fluctuating when pus forms.

What is the treatment of caries and necrosis?

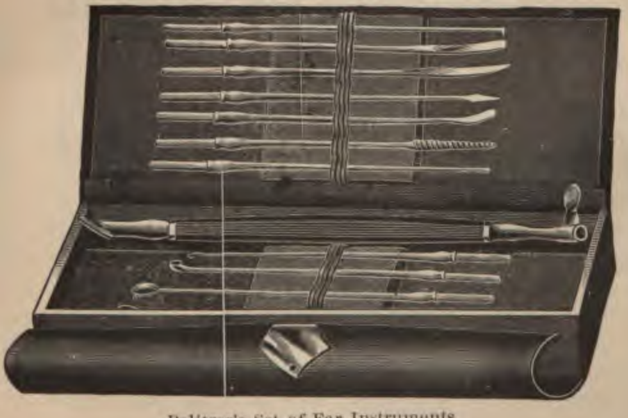
If a sequestrum has formed, it should be removed with forceps. Politzer's forceps (Fig. 62) are usually strong enough for this purpose, but Sexton's foreign-body forceps (Fig. 82) can often be used to advantage. If it be found impossible to remove the sequestrum

FIG. 82.



Sexton's Foreign-body Forceps.

FIG. 83.



Politzer's Set of Ear Instruments.

through the auditory canal because of the granulations and polypi that obstruct the canal, they should carefully be removed by means of a snare; after a few days, in some instances, the sequestrum will have been pushed outward by the granulations behind it into a position where it can readily be grasped by forceps and removed.

In cases of caries or where the necrotic process has not progressed to the formation of a sequestrum, the diseased bone should be scraped away by means of a sharp curette (Fig. 83), and the parts covered with powdered boracic acid or iodoform. When caries or necrosis affects the promontory, only the most superficial curetting is justifiable, but the parts should be kept scrupulously clean, and as *dry* as possible by means of frequent insufflations of powdered boracic acid.

The prognosis of course varies according to the part of the tympanum attacked by necrosis. In individuals otherwise healthy the prospects of a favorable result are encouraging, even when a large portion of the temporal bone is involved by the disease. In tuberculous individuals, however, the disease sometimes progresses toward a fatal termination notwithstanding all efforts to prevent it.

OPERATIONS UPON THE MIDDLE EAR.

For what purpose are operations performed upon the middle ear?

For the improvement of hearing, the relief of tinnitus aurium or vertigo, and to bring about the cure of a persistent discharge from the middle ear.

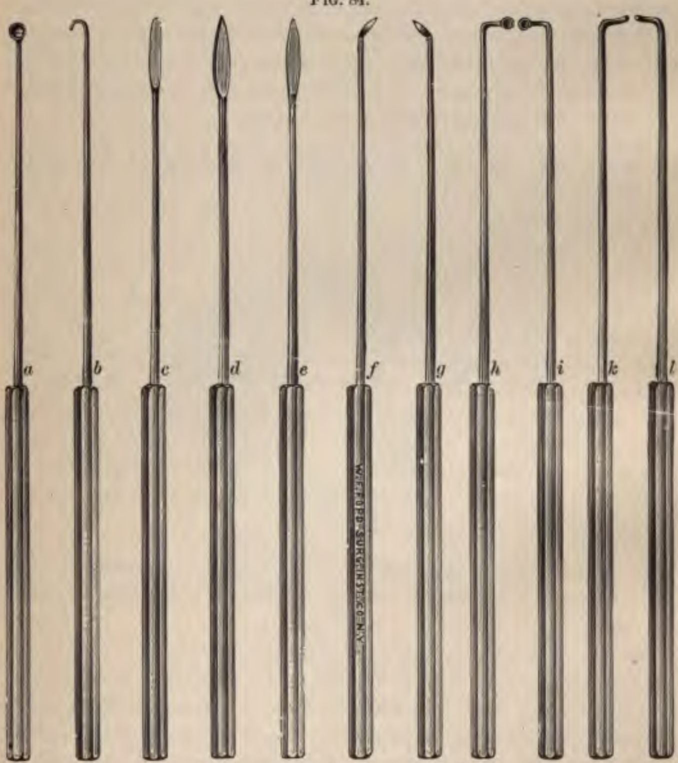
What operations are performed for these purposes?

The operations that have been performed from time to time are quite numerous, the following being a partial list: *Paracentesis*, single or multiple; *excision* or destruction by caustics of a portion of the membrana tympani for the purpose of establishing a permanent opening; *plicotomy* or division of the posterior fold; *section* of the anterior ligament of the malleus; *tenotomy* of the tensor tympani or stapedius muscle, or both; *division* of adhesions between the membrane and promontory or between the ossicles, etc.; *excision* of a portion of the malleus; *disarticulation* of the incudo-stapedial articulation, or division of the descending process of the incus and mobilization of the stapes; *plastic operations* for uniting either the incus or stapes with the membrana tympani; and *removal* of one or more of the ossicles.

For what purpose is myringotomy performed?

For the evacuation of fluids from the cavity of the tympanum or as an exploratory incision to determine the mobility of the stapes

FIG. 84.



Dench's Set of Ear Instruments.

before attempting a more radical operation. When the operation is done for the evacuation of fluids, the cut is generally made in the posterior inferior quadrant, and it should at least be 2 or 3 millimetres in length. The exploratory incision, which is made from just behind the short process, should extend immediately beneath the posterior fold for a sufficient distance to cause considerable gaping of the wound, and to allow the operator to test the mobility of the stapes and observe the condition of the tympanum. The operation does not usually require general anæsthesia, but a 10 per cent. ointment of cocaine and lanolin may be smeared over the parts half an hour before operating. The hearing should be tested before and after the operation, and any improvement noted. The wound of the exploratory incision is brought together, and is held in position by means of a pledget of absorbent cotton.

By what methods may a permanent opening in the membrana tympani be established?

A portion of the membrane may be excised with a knife (Fig. 84, *e*) or by the method of Simrock. A minute portion of concentrated sulphuric acid is held against the membrana at the desired spot by means of a cotton-tipped probe. The acid immediately attacks the membrane, and destroys that portion with which it is brought into contact, so that in the course of a few moments an opening can be made by pushing a blunt probe through the eschar. But little reaction commonly follows the operation, and the opening generally remains patulous for some time *if it is let alone*, and in some cases produces considerable improvement of the acuteness of hearing. A little powdered boracic acid should be insufflated upon the parts as a dressing after the operation.

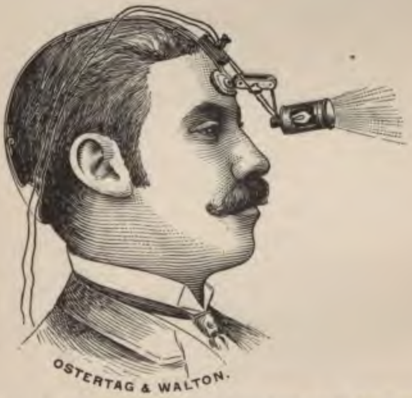
For what purpose are performed multiple incisions of the membrana tympani and tenotomy of the tensor tympani?

These operations have been performed for improvement of the hearing and for the relief of tinnitus. But temporary improvement can be expected as the outcome of either operation. Section of the tensor is probably best performed in the following manner: An angular knife (Fig. 84, *f* or *g*) is thrust through the membrana tympani close in front of, or immediately behind, the malleus handle, and just below the short process. Section of the tendon is accomplished from below upward, the cut through the membrana being extended upward at the same time. The tenotomy should be followed by a vigorous inflation of the tympanum by Politzer's method, in order, if possible, to restore the drum-head to its normal position.

What are the indications for the removal of the membrana tympani, malleus, and incus in chronic catarrh of the middle ear?

The operation is performed for the relief of tinnitus and to improve hearing when milder measures have failed to check the progress of the disease or secure relief from tinnitus. Before determining the advisability of operating the hearing should carefully be tested by means of tuning-forks. If it is found that the acuteness of hearing has been seriously impaired, largely as the result of impairment of the functions of the labyrinth or auditory nerve, but little if any improvement of the hearing-power can be expected as the result of the operation. It may be performed, however, to check the further progress of the disease.

FIG. 85.


OSTERTAG & WALTON.

Gleason's Electric Light for Intratympanic Surgery.

How is the operation performed?

Perfect control of the patient should be secured by the administration of ether, and the operation should be performed with antiseptic precautions. The auditory canal should first be cleansed thoroughly and syringed with a strong solution of bichloride. An electric lamp attached to the forehead (Fig. 85) will be found a convenient means of illuminating the field of operation, although some operators prefer daylight reflected into the canal by means of the forehead mirror. The advantage of the arrangement shown in the cut is that the lantern, containing an ordinary 2 or 3 candle, 4 to 6 volt lamp, can be attached in place of the reflector to the head-band the aurist is accustomed to wear; and if the electric light within the lantern burns out during an operation, it can almost instantly be replaced by a new one. In combination with a small 3-cell Fleming storage battery weighing only 9½ pounds, it yields a 2 to 3 candle-power light for one and a half hours, and is an extremely light and portable outfit.

An incision is first made through the membrana, commencing at a point posterior to the short process and following a curve just below the posterior fold until the middle of the posterior part of the ring is reached. If the incision has been made carefully with a sharp knife in the clear part of the membrana, no bleeding will occur; when the flap is pressed downward, there will be brought into view the incudo-stapedial articulation, which is next divided by means of an angular knife (Fig. 84, *f* or *g*) passed into the tympanum, either in front of or behind the incus shank. By slight traction outward the knife is made to hug the incus shaft, while at the same time the articulation is divided by a downward stroke. Care should be exercised that the articulation is thoroughly divided before attempting any further manipulations. A puncture should now be made with the sharp knife (Fig. 84, *d*) through the membrane at its lowest portion, sufficiently large to permit the introduction of a probe-pointed knife (Fig. 84, *c*), which is made to cut its way upward until the inferior extremity of the original incision is reached. The blade of the knife is now turned in the opposite direction, and the membrana is incised anteriorly up to the anterior fold. Up to this point little or no bleeding will occur to obscure the field of operation.

The next step is to divide the attachments of Shrapnell's membrane and the strong anterior ligament of the malleus. This should be done rapidly, as the hemorrhage will be somewhat profuse. The sharp-pointed knife (Fig. 84, *e*), with its handle depressed until it touches the lower margin of the speculum, is made to pierce Shrapnell's membrane just above the short process, and is thrust inward and upward into the fornix tympani, and is then made to cut its way out downward and backward, thus severing the external and posterior ligaments of the malleus and the posterior portion of the membrana flaccida. The knife is then quickly turned, its point carried over the short process, and made to cut through the anterior segment of Shrapnell's membrane and the strong anterior ligament of the malleus. As soon as the hemorrhage, which may obscure the field of operation, has been checked, the malleus is grasped with Sexton's foreign-body forceps, and, being first pressed inward to free its head from the ledge on which it lies, is brought down and extracted. The superior ligament and the tendon of the tensor tympani both being weak, no force is necessary to rupture them.

After the somewhat free hemorrhage following the extraction of the malleus has been controlled, and the blood removed by means of absorbent cotton wrapped about a probe, the incus, if in sight, is seized with the forceps and removed, traction being exerted first inward, then downward and outward. Frequently the shank of the incus will not be in sight, having been displaced downward and backward during the removal of the malleus. Under these circumstances it is sought for by means of the curved probe (Fig. 84, *k* or *l*). The end of the probe is carried into the tympanum with its curve directed backward and then rotated upward, until the incus is brought into view. This manœuvre will perhaps have to be repeated several times before this result is accomplished.

After the operation all blood should be removed from the tympanum and canal by means of absorbent cotton wrapped about the end of a probe, and a plug of iodoform gauze loosely inserted into the auditory canal.

Many operators advise the removal of the incus before the malleus. If, after the incudo-stapedial articulation has been severed, the incus shank is clearly discernible, it is best, in most instances, to at once grasp and remove it with a suitable pair of forceps, thus avoiding the necessity of searching for, and perhaps being unable to discover, it at a subsequent stage of the operation. Before closing the auditory canal with gauze it is best in all instances to test the mobility of the stapes. If this bone is bound down by adhesions, they should be severed, and if the adhesions are so extensive as to render it probable that they will so re-form as to interfere with the mobility of the stapes, the head of this bone should be grasped with forceps and extracted, or it may be removed by means of a hook. Great care should be exercised not to dislocate the bone inward into the labyrinth while executing these manœuvres.

After the operation the tympanum should be dried with absorbent cotton and lightly dusted with iodoform, and the tympanum and canal very loosely packed with a narrow strip of iodoform gauze in order to check any oozing and to serve as a drain. The packing is removed at the end of twenty-four hours, and, if necessary, another strip of iodoform gauze inserted, after cleansing and drying the parts by means of absorbent cotton wrapped about the end of an Allen probe (Fig. 34). Further treatment will depend upon the amount of reaction following the operation. Rarely, severe pain occurring a few hours after the operation requires the removal of the packing and *very* gentle syringing with hot distilled water to which boric acid or carbolic acid may be added. The ear should be protected by means of a pledget of absorbent cotton placed loosely in the canal, and should be changed by the patient if it becomes saturated with discharge. The parts should be inspected once a day by the surgeon, and if no discharge is present the middle ear at least should not be disturbed, If, however, there be a discharge, the parts should be gently but carefully cleansed by means of absorbent cotton dipped in a solution of peroxide of hydrogen, and a little powdered boric acid dusted over the parts after they have been thoroughly dried. A slight serous discharge for a few days after the operation is not uncommon, but suppuration rarely occurs. Vertigo and nausea are generally complained of for a few days, if the stapes has been roughly manipulated or removed.

What is the prognosis of this operation?

Tinnitus is usually at least alleviated, but the results as regards the hearing are so uncertain that there has been a growing disposition manifested during the past two years, on the part of those who previously performed the operation most frequently, to abandon it in favor of simpler proceedures. The operation has the advantage of permitting free access to the tympanum for subsequent mobilization of the stapes or the division of adhesions should it be necessary. Ordinarily the drum-head is replaced, in whole or in part, by cicatricial tissue, which, if it interferes with the acuteness of hearing, will require removal, the operation being repeated as often as necessary; whilst the absence of the drum-head permits the entrance of dust and other materials into the middle ear, which consequently may readily become infected. Apparently, the idea that the presence or absence of the membrana tympani greatly increases or decreases the hearing when the Eustachian tube is patulous is a myth, but the chief function of this structure—namely, the exclusion of dirt from the middle ear—is of the greatest importance, and should not be impaired by an operation for the relief of deafness and tinnitus unless absolutely necessary. In many instances equally good results, as far as the relief of tinnitus and the improvement of the hearing are concerned, can be secured by severing the incudo-stapedial articulation and mobilizing the stapes—with or without tenotomy of the stapedius muscle.

Describe the operation for severing the incudo-stapedial articulation and mobilizing or extracting the stapes.

A general anæsthetic may be administered, but it is preferable to operate under cocaine-anæsthesia in order to secure the co-operation of the patient and to test his hearing from time to time during the different stages of the operation. The field of operation is prepared, upon the preceding day, by carefully cleansing the auditory canal with a solution of peroxide of hydrogen and syringing with a 1 : 2000 solution of corrosive sublimate, after which the auditory canal is stopped with a plug of iodoform gauze. All instruments, the absorbent cotton, and the solutions of cocaine are sterilized in the usual manner by heat. Partial anæsthesia is secured by lightly packing the auditory canal with absorbent cotton dripping with a 10 per cent. solution of cocaine, which is allowed to remain for from half an hour to an hour. Owing to the fact that watery solutions do not readily penetrate the epidermis, anæsthesia is never complete as the result of this proceedure, and hence the first incision through the membrane causes a slight amount of pain. Dench prefers to employ a 10 per cent. ointment of cocaine in lanolin, which is carefully rubbed into the parts; but according to the author's experience the results even with the ointment are not altogether satisfactory.

The pain of the first incision is, however, never severe, and if a 10 per cent. solution of cocaine be applied to the cut surfaces and to the mucous membrane from time to time, the rest of the operation is nearly painless.

Commencing rather below the middle of the posterior periphery of the drum-head, an incision is made and prolonged upward with the probe-pointed knife (Fig. 84) through the clear portion of the drum-head close to the annulus, beneath the posterior fold, and for a short distance downward along the malleus handle (Fig. 86). Little more than a fraction of a drop of blood ordinarily follows the incision, but the flap should be turned forward, and a pledget of absorbent cotton wrapped about the end of an Allen probe and saturated with a 10 per cent. solution of cocain should be held in contact with the cut surfaces and the tympanic mucous membrane until all bleeding has ceased. Before proceeding further with the operation, it is well to test the patient's hearing with both the voice and the watch, in order to ascertain if any improvement in the hearing has resulted from the artificial opening in the drum-head. This is rarely the case.

FIG. 86.

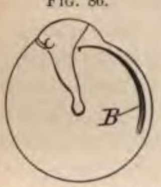


Diagram of the left membrana tympani: *B*, incision through the drum-head.

Generally, when the flap is turned forward it remains in that position, and a good view of the interior of the drum is obtained. The region of the round window should carefully be inspected, and any abnormality noted and remedied, if possible, at a subsequent stage of the operation. If the incudo-stapedial articulation is not visible, it is brought into view by inclining the patient's head strongly toward his opposite shoulder so that it is possible to see upward beneath the posterior fold. The incus-hook (*b*, Fig. 84) should now be passed around the descending process of the incus close to the stapes, and an effort made to mobilize the ossicles by gentle traction in anterior, posterior, and lateral directions, and any improvement in the patient's hearing noted. If none occurs, the tendon of the stapedius muscle should next be divided with the point of the sharp-pointed knife (*e*, Fig. 84) by a downward stroke close behind the incudo-stapedial articulation. Sometimes the tendon gives way with an audible snap and immediate improvement in the patient's hearing follows. If, however, the hearing is not improved, the incudo-stapedial articulation should be severed by means of an angular knife (*f* or *g*, Fig. 84), which is made to cut downward through the joint either from in front of or behind the incus-shank, which it hugs closely while the downward stroke or strokes are being made. If the knife cannot readily be passed beyond the incus-shank either in front or behind it, the joint may be severed from below with the point of the knife. The knives (*f* and *g*, Fig. 84) are not double-edged, because it is difficult to sharpen a knife of that character so that it will cut through the incudo-stapedial articulation readily without employing more force than is ordinarily judicious. After the incudo-stapedial articulation has been severed the incus-shank is pushed forward and upward in order to diminish the possibility of its tip re-uniting with the stapes. Some operators employing general anæsthesia, notably Charles Burnett, prefer to remove the incus entirely, in order to prevent the possibility of adhesions forming between that ossicle and the stapes. After severing the incudo-stapedial joint, if the patient's hearing still remains unimproved, the point of the sharp-pointed knife may be cautiously carried about the head of the stapes, within the pelvis of the oval window, and an attempt made to mobilize the stapes by means of an Allen probe about the end of which a few fibers of cotton have been wrapped. The head of the stapes should be gently pressed upward, then backward, then forward, care being exercised that sufficient force is not employed to endanger fracturing the crura of the stapes, which, as the result of atrophic changes, are sometimes very fragile. If, in spite of these manipulations, the bonelet remains firmly fixed and the patient's hearing unimproved, an attempt may be made to remove the ossicle by traction with a hook or with Sexton's ring forceps. If bony ankylosis exists between the foot-plate of the stapes, Politzer has shown by experiments on the cadaver that the effort will not succeed, but that the crura will be fractured in the effort to remove the stapes. A portion of the foot-plate may, however, be removed with the fragment of the crura of the stapes, and the patient's hearing improved.

Although the stapes has been removed successfully without general anæsthesia, it is probably best in all instances requiring the removal of this ossicle to determine the matter before the operation by means of tests already mentioned, and administer ether.

After the completion of the operation the edges of the wound in the drum-head are brought together and supported by a small amount of boric acid or iodoform insufflated by means of the powder-blower; and, if necessary, a small piece of sterilized absorbent cotton may be inserted to retain the edges of the wound accurately in contact. Ordinarily the edges of the wound quickly unite, but suppuration has been reported as following the operation in a few instances.

What is the prognosis of the operation?

In all intra-tympanic operations, the prognosis is uncertain. Good results have been reported by numerous operators as following severing the incudo-stapedial articulation and mobilizing the stapes with or without the removal of the incus. The prognosis as regards diminishing tinnitus is much better than that of improving the hearing to a useful degree.[1]

From the published reports intra-tympanic operations seem remarkably free from risk. In several instances, however, persistent suppuration has followed intra-tympanic operations in catarrhal cases. A slight amount of serous discharge for a few days after the operation is not unusual. In one case reported by Randall the unintentional dislocation of the incus backward into the antrum was followed by mastoid abscess requiring surgical interference. Both Ludewig and Dench have reported cases in which the facial nerve has been injured by the incus-hook, with resulting temporary facial paralysis.

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[1] Of twelve cases operated upon by the author, tinnitus when present disappeared or was greatly alleviated in all, but hearing was only greatly improved in four. In some of the cases vertigo followed the operation, persisting for a few hours, and in one instance for about three days. In one case—that of a bleeder—hemorrhage prevented completion of the operation, but the drum-head was subsequently opened by Simrock's method and the incudo-stapedial articulation severed, with the result of greatly alleviating tinnitus and slightly improving the hearing for the voice. In none of these cases was hearing for the watch permanently improved. In one of the twelve cases the crura of the stapes and a portion of its foot-plate were removed. In this instance nausea and vomiting followed the operation and persisted for three or four days. Vertigo also caused considerable discomfort for two or three weeks. The hearing for conversation, at first greatly improved, gradually declined, until at the end of two years the improvement, at first manifest to both the patient and her friends, became by no means so apparent. Tinnitus entirely disappeared.

Theoretically, the removal of the stapes would seem to leave the way open for infection of the labyrinth from the tympanum. When the operation is performed in suppurative cases the danger is apparent, and the fact that no cases have been reported is probably the result of the careful asepsis observed.

It seems probable that in most instances the impairment of hearing and tinnitus is due in catarrhal cases to immobility of the stapes, and that the improvement as regards tinnitus and hearing in removal of the drum-head and larger ossicles has resulted from intentional or unintentional mobilization of the stapes while severing the incus from the stapes. It also appears probable that in most instances any improvement will not be permanent. Stapedectomy was theoretically a promising operation, but the results are disappointing, owing to the fact that in true bony ankylosis the crura are usually broken off in the effort to remove the ossicle, and only a portion, if any, of the foot-plate is brought away. Even in fortunate results following the operation, the improvement could scarcely be permanent, because the progress of the disease is not prevented by the removal of the stapes. Politzer has shown that the cause of bony ankylosis of the stapes is a "circumscribed primary affection of the labyrinthine capsule, exhibiting post-mortem, in the region of the niche of the oval window, more or less sharp bony protuberances, covered mostly with normal mucosa, the neoplastic bony tissue gradually pushing aside the normal bone and attacking the oval window and stapes, producing ankylosis of the stapes. The round window may also be very much contracted.

This contribution of Politzer to our knowledge of the pathology of so-called "dry catarrh of the middle ear" is the most important in recent years, and fully explains the poor success following intratympanic surgery in such cases. Politzer regards the prospect of curing the disease as nearly hopeless, but thinks that its rapid progress might be stayed by the local use of iodine vapor and the internal administration of iodide of potassium.

It will readily be seen that the pathology of the ossicular articulations in this disease is somewhat similar to that of rheumatic or gouty joints in other parts of the body,—a fact to which Wilde[1] and Toynbee[2] long ago called attention.

The ossicles are sometimes affected by osteoporosis or osteosclerosis,—conditions in which the bony walls of the tympanum and the mastoid ordinarily participate. Von Tröltsch long ago called attention to the unfavorable effect upon the hearing that partial or complete obliteration of the mastoid cells, as the result of chronic middle-ear catarrh, may exert upon the hearing.[3] The ossicles are not infrequently deformed as the result of exostoses. One or more of their articulations may be ankylosed, and the presence of either an exostosis or a deposit of chalk may cause the foot-plate of the stapes to project into the vestibule, as in the twelve cases noted by Toynbee, whose catalogue describes 136 instances of ankylosis of the foot-plate of the stapes to the oval window among his 1013 specimens.[4]

The niche of the round window is sometimes nearly or completely obliterated by hypertrophy of its mucous membrane, or, as the result of long-contined intra-tympanic catarrh, it may be covered by a more or less rigid pseudo-membrane or completely filled with a plug of connective tissue.[5]

Membranous bands extending across the tympanum exist in about 80 per cent. of normal ears, and it is well to bear this fact in mind and carefully distinguish between such normal structures and fibrous synechiæ binding the intra-tympanic contents together. Extensive synechiæ of the membrana tympani are frequently formed during the middle-ear catarrhs of childhood, for obvious reasons; and when adhesive processes within the tympanum are very extensive, the incudo-stapedial articulation and the tendon of the tensor tympani are almost invariably involved. In some cases the stapes is immovably fixed by synechiæ or even by little osseous connections.[6]

It seems hardly necessary to remark, in connection with the pathology of chronic catarrh of the middle ear, that whilst the disease is generally readily curable in its earlier stages, when the intra-tympanic articulations, ligaments, and muscles are all profoundly involved the affection is as incurable by massage or any therapeutic measure as advanced arthritis deformans.

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[1] *Diseases of the Ear*, by William R. Wilde, pp. 222, 242, 333.

[2] *Diseases of the Ear*, by Joseph Toynbee, 2d Amer. ed., p. 298.

[3] *Diseases of the Ear*, by Anton von Tröltsch, 2d Amer. from 4th German ed., pp. 335-337.

p. 301.

[5] *Ibid.*, p. 284.

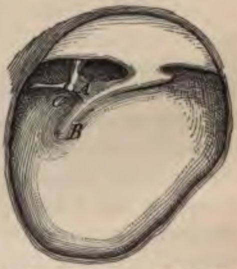
[6] *Ibid.*, p. 284.

What operations are done for the relief of deafness and tinnitus resulting from chronic suppuration of the middle ear?

Division or divulsion of false membranes and adhesions binding the ossicles together or to the tympanic walls in such a manner as to interfere with the vibration of the stapes; mobilization or removal of the stapes; removal of the remains of the drum-head and the two larger ossicles.

In most instances the first ossicle to become carious or necrosed as the result of chronic intra-tympanic suppuration is the incus, because of its imperfect blood-supply as compared with that of the other intra-tympanic structures. Burnet states that the entire bonelet may disappear as the result of a few weeks of intra-tympanic suppuration. Ordinarily the descending process is the first portion of the incus to disappear, thus freeing the incus. The comparatively good hearing of patients with large dry perforations of the membrana is due in many instances to the fact that the stapes is thus freed at an early stage of the suppurative process, and does not become involved by subsequent contractions and adhesions. In some instances, however, this fortunate result does not occur, and the detached stapes may be completely buried in a mass of cicatricial tissue which holds it immovable in the pelvis of the oval window. When not detached from the incus the movements of the stapes may be interfered with by bands of tissue binding the two larger ossicles together or to the tympanic

FIG. 87.

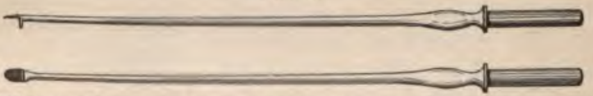


A, Band of connective tissue extending from the long process of the incus, *C*, to the malleus-handle, *B*, which was adherent to the promontory. Hearing for the watch increased from 2 inches to 2 feet as the result of divulsing this band by gentle traction with an Allen probe, the point of which was bent nearly at a right angle and inserted underneath the band. The improvement lasted for nearly three years, when the operation was repeated with equally satisfactory results.

wall. The most common of such bands is one extending from the long process of the incus to the tympanic wall and the malleus-handle (Fig. 87).

Division or divulsion of such bands is in some instances followed by the most astonishing improvement in the hearing power and the complete relief of tinnitus. In suitable cases more permanent results are secured by divulsion or stretching of the bands than by cutting them. In some cases the vibrations of the ossicular chain are interfered with by an adhesion of the remains of the drum-head to the promontory in such a manner as to bind down the malleus-handle. Under such circumstances division of the adhesion is followed by improved hearing and decreased tinnitus. In most instances divulsion of intra-tympanic bands and adhesions will have to be repeated from time to time in order to secure permanent results; but as the operations are by no means formidable, they may be done during an ordinary office visit when required. In the divulsion of bands and adhesions care should be exercised that sufficient force is not employed to endanger dislocation of one of the ossicles, more especially the stapes. For the division of adhesions between the crura of the stapes and the walls of the oval window Politzer has devised a special knife (Fig. 88). After division of synechiæ and surgical mobilizing of the stapes the hearing power can sometimes be increased by the use of an artificial drum-membrane; for this purpose a membrane made of paper, as first employed by Blake, answers an admirable purpose, and is sometimes followed by so much permanent improvement of the hearing that its use can finally be dispensed with. The permanent improvement is doubtless due to "auto-mobilization" of the stapes during hearing as the result of wearing the disk.

FIG. 88.



Politzer's synechtotomy-knife, for division of bands extending from the crura of the stapes to the walls of the oval window.

The removal of the two larger ossicles, or what remains of them, may in certain rare cases be admissible as a means of improving the hearing or diminishing tinnitus; but cases are hardly conceivable in which all the improvement possible, as regards both tinnitus and hearing, cannot be secured by the division of adhesions, disarticulation of the incudo-stapedial joint, or mobilization of the stapes.

What is the history of intra-tympanic operations for the relief of deafness and tinnitus?

The history of intra-tympanic operations for the relief of deafness and tinnitus is somewhat interesting. The accidental rupture of the drum-head having resulted in the improvement of a deaf person's hearing, Riolan proposed making an artificial opening in the membrana tympani as a remedy for deafness. Experiments upon dogs and other animals as to the effect of the excision of a portion of the drum-head having yielded inconclusive results, Cheselden, the father of English surgery, wished to perform the operation upon a criminal condemned to death, who was to obtain his release on account of it. In a foot-note Wilde[1] says that the case is referred to in Walpole's "Reminiscences," where it is stated that the criminal was the surgeon's cousin; and that he was actually pardoned through the intercessions of Lady Suffolk (mistress to George II.), who, being deaf, wished to have the experiment tried; but the operation was not performed, owing to the popular outcry against it.

In 1800, Mr. (afterward Sir) Astley Cooper published a letter in the *Philosophical Transactions* entitled "Observations on the Effects which take place from the Destruction of the Membrana Tympani of the Ear," and soon afterward obtained a medal from the Royal Society on account of the success that, in a few cases, followed the operation of puncturing the drum-head for the relief of deafness.

Toynbee[2] says of the operation: "In Sir Astley Cooper's successful cases there was simple obstruction of the Eustachian tube; and there is little doubt that the affection would have yielded to simpler measures having for their object the removal of the obstruction, while the cure, instead of being temporary, would have been permanent. In the great majority of cases where Sir Astley Cooper punctured the membrana tympani not the slightest benefit accrued, because the deafness was dependent upon other causes than obstruction of the Eustachian tube; and in some cases of deafness from debility of the auditory nerve the shock of the operation greatly aggravated the symptoms."

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[1] *Diseases of the Ear*, by William R. Wilde, p. 33.

[2] *Ibid.*, p. 240.

In 1846, Dr. Butcher read a paper before the Dublin Surgical Society on the evil results of perforating the membrana, and reported two deaths as having apparently occurred as the result of the operation.[1]

Notwithstanding the fact that Sir Astley Cooper soon abandoned perforating the drum-head as a remedy for deafness, his instruments and the technique of his operation were modified and improved by Himley, Itard, Delau, Fabrigi, and others; while the operation became very common upon the continent of Europe, but was gradually nearly abandoned there also. Like the modern operation for the removal of the drum-head, malleus, and incus, Sir Astley Cooper's operation was done in many instances where a judicious surgeon should have known beforehand that nothing but harm could result from the procedure.

In connection with the history of intra-tympanic operations it is interesting to note the fact that while it is generally believed that Sir Astley Cooper was the first surgeon to perforate the membrana tympani for the relief of deafness, von Tröltsch states that the operation was first performed in Paris, about 1760, by Eli.[2]

An essay of sixty-two pages was published in Edinburgh, in 1788, by Dr. Peter Degravers, in which he states that he completely removed the membrana tympani in one case, and, again, says: "I incised the membrana tympani of the right ear with a sharp, long, but small lancet. I left the patient in that state for some time, and afterward observed that it had re-united. . . . I incised again the membrana tympani of the right ear, but crucially; and, on removing the parts of the membrane incised, I discovered some of the ossicles, which I brought out."[3]

The uncertain results following the establishing of an artificial opening in the membrana tympani, and the impossibility of keeping the aperture long open, were the causes of the operation being nearly abandoned. During the decade 1860–70 the operation again became somewhat common upon the continent of Europe, and the failures of fifty years before were repeated. Catgut strings, lead wire, whalebone pegs, silver canulas (Bonnafont), vulcanite eyelets

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[1] Quoted by Wilde, p. 286.

[2] *Ibid.*, p. 384.

[3] *Ibid.*, p. 30.

(Politzer), aluminum and gold canulas of horseshoe shape, fastened around the handle of the malleus to prevent their dropping into the tympanic cavity (Voltolini), were employed with the object of obtaining a permanent opening in the membrana, and all failed. Sooner or later they were expelled and the opening cicatrized, sometimes, however, only after a long and tedious intra-tympanic suppuration.

Schwartze, in 1873,[1] to prevent the closure of an artificial opening in the membrana, removed the entire drum-head and the malleus. The results of his operations were not satisfactory, as in the majority of his operations the drum-head was replaced by cicatricial tissue that required subsequent removal. In 1878, Kessel removed the drum-head, malleus, and incus in a number of cases, with the result of diminishing the tinnitus and improving the hearing—results that remained somewhat permanent in spite of the regeneration of the drum-head. In 1885,[2] Lucae reported 56 operations in non-suppurative otitis media where the drum-head and malleus were removed and, in 6 of the operations, the incus also. In 9 of the cases operated upon the improvement in hearing was considerable; in 19 it was slight; in 18 there was no improvement at all; and in 7 cases the hearing was worse after the operation.

The operation of the removal of the drum-head, malleus, and incus was first done in America at New York, in 1886, by Samuel Sexton,[3] and shortly afterward in Philadelphia, by Burnett.[4] The operation soon became very common, and bad results multiplied, partly as the result of the faultiness of the operation itself, and partly as the result of the selection of cases unsuitable for operation by men apparently more anxious to achieve a reputation as skilful operators than as judicious surgeons. At the present time the operation for the removal of the drum-head, malleus, and incus, in non-suppurative cases, seems to be in rather bad repute, and there has developed a disposition to abandon it entirely. Probably even those American aurists who have performed the operation most frequently would entirely agree with Schwartze, who, as the result of an experience of more than twenty years, during which time he has done the operation each year less and less frequently, merely says of it that it is not entirely contraindicated. Dench[1] is now probably the only American author who distinctly advises its performance, but, apparently, only with the object of facilitating the mobilization of the stapes, from time to time, in cases that require this procedure.

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[1] *The Ear and its Diseases* (Sexton), p. 359.

[2] *Archiv für Ohrenheilk.*, vol. xxii. Also quoted by Politzer, *Diseases of the Ear*, p. 324; Sexton, *The Ear and its Diseases*, p. 364.

[3] *Ibid.*, p. 368.

[4] In 1888. *Ibid.*, p. 367.

In 1892, Jack[2] reported the results of 16 operations for the removal of the stapes, and in the following year the results in 32 additional cases.[3] Both Jack and Blake, of Boston, have performed the operation somewhat frequently, but without uniformly beneficial results, the larger percentage of good results being obtained in suppurative cases, where it is probable that in many of the cases operated upon an equally good result might have been secured by a simpler and less serious operation. Of the 21 cases of removal of the stapes in non-suppurative cases reported by Blake in 1893,[4] there was a noticeable improvement in the hearing in only 3; and only in 2 of these 3 was there improvement in the hearing sufficient to be of any practical benefit.

What conditions prevent the cessation of a chronic discharge from the middle ear?

Polypi; a pulpy or granular condition of the mucous membrane; insufficient drainage, because of a small perforation or one unsuitably situated; necrosis of one or more of the ossicles or of the tympanic walls; and cholesteatoma.

What is the treatment?

The treatment of polypi and granulations has already been described.

In some instances, where a large perforation exposes swollen or granular mucous membrane upon the promontory, rapid cessation of a chronic discharge will be brought about by lightly touching the parts once or twice a week with a 25 per cent. solution of chloracetic acid in conjunction with the treatment already advised for chronic suppuration. Small perforations should be enlarged to a size sufficient to permit the use of the intra-tympanic syringe.

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[1] *Diseases of the Ear* (Dench), p. 484.

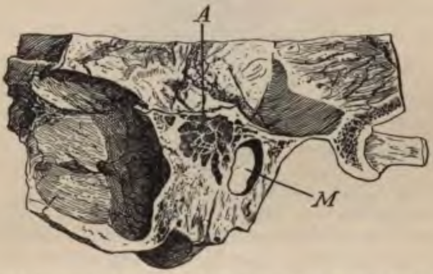
[2] "Remarkable Improvement in Hearing by Removing the Stapes," by Frederick I. Jack, M. D., in *Trans. of the Amer. Otological Society*, 1892.

[3] "Further Observations on Removal of the Stapes," *Ibid.*, 1893.

[4] "Stapedectomy and other Middle-Ear Operations," by Clarence J. Blake, *ibid.*, 1893.

If possible, sequestra should be removed by means of forceps as already described. The mere presence, however, of localized spots of necrosis or caries upon one of the larger ossicles is hardly a sufficient reason for its removal. Perfect cleanliness and good drainage is ordinarily sufficient to bring about a cure of the condition. The rubbing of the parts with a cotton-tipped Allen probe that has been dipped in peroxide of hydrogen, and proper daily intra-tympanic syringing will have a stimulating action upon the parts and will aid the proliferation of epithelium over the diseased area.

FIG. 89.

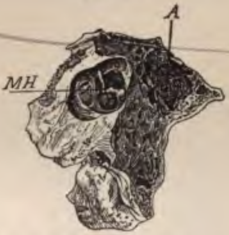


Vertical Sagittal Section through a Left Temporal Bone; median surface of the lateral portion. The mastoid antrum, aditus, and attic of the tympanum are filled by a cholesteatoma. The mastoid process is sclerosed, and its pneumatic cells are few and small. *A*, antrum containing a portion of the cholesteatoma; *M*, auditory meatus (from a photograph of a specimen in the author's collection).

Doubtless it is advisable, after milder treatment has failed, in carefully-selected cases to excise the remains of the membrana tympani and one or more of the ossicles as part of the treatment of an otherwise intractable suppuration of the middle ear. Yet it would seem that the aurist who habitually resorts to this operation "as a routine treatment in nearly all chronic suppurations of the middle ear" does so as a sort of confession of his incapacity, and should be placed in a catalogue of incapables with surgeons who amputate in all cases of necrosis of the bones of the extremities, or oculists who do tenotomies in cases of strabismus that are amenable to treatment by appropriate glasses.

When the attic has become epidermized, scales of epidermis will be exfoliated from time to time, until a little ball of cholesteatomatous material will have collected in the attic and perhaps have extended into the aditus as well. The disintegration of such masses is a common cause of chronic suppuration and the growth of polypi. Randall thinks that in every case of long-continued suppuration the presence of cholesteatoma may be suspected. It is rare to fail to remove by intra-tympanic syringing of the attic cholesteatomatous scales in cases of long-continued middle-ear suppuration in which the discharge originates within this cavity. The removal of such little masses, and also the granulation-tissue or small polypi that their presence commonly causes, will in most instances be all that is necessary to bring about a cessation of a chronic discharge that may have persisted for years. Under such circumstances the hearing is often greatly improved. In rare cases it is impossible to remove the

FIG. 90.



Lateral Surface of the Median Portion of the Same Specimen. A part of the auditory meatus has been cut away and the specimen tilted toward the right in order to show the membrana tympani in the photograph, which is on a somewhat larger scale than Figure 89. *A*, aditus containing part of the cholesteatoma, which extends into and completely fills the attic. The tegmen of the aditus and antrum is extremely thin and discolored about a small perforation that extends from the antrum into the middle cranial fossa. *M. H*, malleus-handle attached to the promontory throughout its entire length in such a manner that the portion of the atrium anterior to the malleus is the only part of the middle ear communicating with the Eustachian tube. The membrana tympani is cicatricial and collapsed. There are two large perforations posterior to the malleus-handle, and one anterior.

cholesteatomatous masses and granulation-tissue within the vault of the tympanum without securing more room for the manipulation of instruments. This may be accomplished to a somewhat limited extent by the removal of the remains of the two larger ossicles, for usually, in cases requiring operative interference, the malleus and incus have been partially destroyed by caries. It should be borne in mind, however, that the removal of these ossicles is rarely, if ever, necessary except for the purpose named. Theoretically, it would be impossible to expect any improvement in the hearing unless during the removal of the ossicles adhesions were ruptured that interfered with the vibration of the stapes. In most instances where it is necessary to resort to operative procedures for bringing about a cessation of a chronic otorrhea, the mere removal of the remains of the two larger ossicles will not be sufficient, and it is far preferable to resort to Stacke's operation, which consists in chiselling away the posterior upper wall of the bony meatus in order to gain ready access to the attic, aditus, and, if necessary, the mastoid antrum. Stacke's or some similar operation would certainly be necessary to bring about a cure of the chronic otorrhea resulting from a condition similar to that existing in Figures 91 and 92, for it will be observed that the cholesteatomatous mass occupies the mastoid antrum as well as the attic, and it would be absolutely impossible to remove such a mass except through a comparatively large opening. It should be borne in mind, however, that no operative procedure, even the establishing of a large permanent post-auricular opening, can be expected to bring about a permanent cure of chronic otorrhea due to the presence of cholesteatoma. Reinhard states that membranes still continued to exfoliate in the cases that he had operated upon by establishing a large permanent post-auricular opening into the antrum, and required removal to prevent the recurrence of suppuration; "in some more frequently, sometimes but once in three years." The same rule applies to all cases of chronic suppuration where the middle ear has become epidermized. Whether an operation has been performed or not, cholesteatomatous masses will form, and their removal from time to time is necessary in order to prevent a recurrence of the suppuration.

Where the middle ear is comparatively dry, exfoliated epidermis will often remain for a considerable period within the middle ear without giving rise to suppuration. In one case the author had succeeded in bringing about a cessation of a tedious otorrhea after the removal of the remains of the malleus and incus. One year afterward the patient complained of a sense of fulness in his ear, and there were removed from his attic epidermal scales, some of which were stained with pyoktanin, which had been used in the treatment of his ear the year before.

Relapses after mastoid operations are notoriously frequent, and in all such cases the necessity for a secondary operation is the accumulation of cholesteatomatous masses within the middle ear. In some instances years may elapse before such masses cause marked aural symptoms, but finally suppuration occurs, and the mastoid antrum has to be reopened to permit the removal of material that fails to find a ready exit through the tympanum and the auditory canal.

In some instances nature does a Stacke operation as the result of necrosis of the lateral bony attic wall, or a large permanent postauricular opening may occur behind the auricle, leading directly into the antrum. In either case the middle ear becomes completely epidermized; but suppuration tends to recur if epidermal scales are not removed from time to time. The advantage of such large openings, secured either by art or by nature, is that epidermal scales and other débris can be readily removed either by the aurist or by the patient and his friends.

Describe the operation for the removal of the remains of the drum-head, malleus, and incus in suppurative cases.

The operation may be done under cocaine-anæsthesia, or a general anæsthetic may be employed. When a large amount of the intratympanic mucous membrane is exposed as the result of disease, except in nervous patients, the employment of a 10 per cent. solution of cocaine yields very satisfactory results if allowed to remain in contact with the parts for some time previous to commencing the operation. If much curetting, however, is to be done after the removal of the malleus and incus, it is better to secure perfect quiescence of the patient by administering ether or chloroform.

If the incudo-stapedial articulation is intact and visible, it is well to begin the operation by severing the joint, to avoid possible injury to the stapes while removing the incus. If the membrana flaccida is intact, the sharp-pointed knife (*e*, Fig. 84) is thrust through it behind the short process, as close as possible to the margin of the annulus, and the incision continued backward and downward for a sufficient distance to completely sever the posterior attachments of the malleus. Without removing the knife from the wound, its edge is turned in the opposite direction, its point is slightly withdrawn so as to ride over the malleus above the short process, and the anterior attachments of the malleus are rapidly severed. Considerable hemorrhage will probably follow the cutting, but the short process of the malleus will probably remain visible for a length of time sufficient to permit the neck of the bone being seized with Sexton's foreign-body forceps, and an effort made to dislodge the head of the malleus from the scute or shelf of bone on which it lies in the lateral portion of the attic, by gentle pressure inward and downward with the forceps. Should gentle manipulation not succeed, it is probable that the malleus is held in position by adhesions to the tympanic walls. Hemorrhage should first be controlled by packing the tympanum and canal with small dossils of absorbent cotton, and then any adhesions that can be reached should be severed by means of angular knives (*f* and *g*, Fig. 84). By means of one of these knives or the incus-hook (*b*, Fig. 84) traction directly outward should be made upon the tip of the malleus-handle until the head of the bonelet is dislodged inward. If now the bonelet be seized in the neighborhood of the short process with the foreign-body forceps, it will readily be removed by traction—at first inward and downward and then outward.

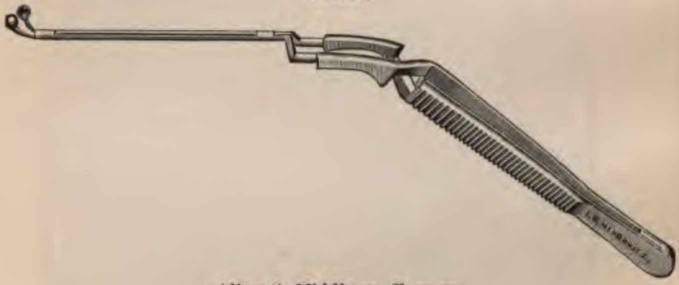
The malleus when withdrawn from the ear should be inspected carefully to determine whether or not the incus is adherent to it. In not a few instances the bonelets will be found firmly bound together by bony ankylosis or strong fibrous bands, so that both bonelets will be removed together. If this does not occur, and the presence of the incus has been determined previous to the operation by the use of an Allen probe the tip of which has been bent upward and guarded by a few fibres of cotton wrapped about it, a diligent search should be made for the incus by means of incus-hooks (*k* and *l*, Fig. 84). The incus will probably be found behind the annulus, dislocated downward and outward as the result of the withdrawal of the malleus. The tip of its long process will probably be found close behind the annulus posteriorly and somewhat below the middle of the tympanum. If the incus-hook (*k* for the left ear, or *l* for the right ear, Fig. 84) be introduced into the lower part of the tympanum, with its concave surface upward and the tip of the hook behind the annulus, by lifting the hook slightly upward and at the same time rotating it the long process of the incus will probably be pushed anteriorly into view from behind the annulus. In executing this manœuvre it is necessary that the tip of the hook be held somewhat closely in contact with the median surface of the annulus. The rotation of the hook may have to be repeated several times before the incus-shank is brought into view. The ossicle will probably be found lying somewhat lower down in the tympanum than would naturally be expected, but if careful manipulation of the hook fails to locate it in this region, the ossicle should be searched for higher up, and if necessary the other hook may be inserted with its concavity downward and its tip behind the scute, and rotated in such a manner as to dislocate the ossicle downward. This manœuvre should be executed with great care and gentleness, as there is danger of pushing the ossicle backward into the antrum. After the incus is brought into view it should be seized with the forceps manipulated in such a manner as to free it from the annulus, and withdrawn.

It should be borne in mind that the first portion of the ossicle destroyed by caries is the long process, and that it sometimes requires but a short period of suppuration to cause the entire destruction of this ossicle. Too prolonged search for the incus after the removal of the malleus is not advisable, unless it is certain from previous examinations that the incus is certainly present.

After the withdrawal of the incus, the edge of the annulus and the tympanic vault should carefully be searched, by means of a cotton-tipped probe, for exposed bone or areas of granulations. If such spots be found, they should carefully be curetted by means of a bent curette (*h* or *i*, Fig. 85). The success of the operation in bringing about a cessation of persistent or recurrent suppuration will often depend upon the thoroughness and care with which this is done. Any remaining portions of the membrana should also be removed with the probe-pointed knife or with a curette.

The remains of the incus, even when firmly bound down by adhesions, polypi, and cholesteatomatous material, may readily be removed by means of Allport's ingenious curette forceps (Fig. 91). The closed blades of the instrument are introduced into the attic, then cautiously opened, and the incus or a polypus searched for. When something is felt to be within the grasp of the little curettes in which the blades terminate, the instrument is withdrawn. This manœuvre is repeated until the attic is completely emptied of all morbid material. Sometimes comparatively large polypi—whose presence in the attic is unsuspected because they cannot be seen —are removed in this manner, and the incus, although unseen, can usually be extracted with comparative ease.

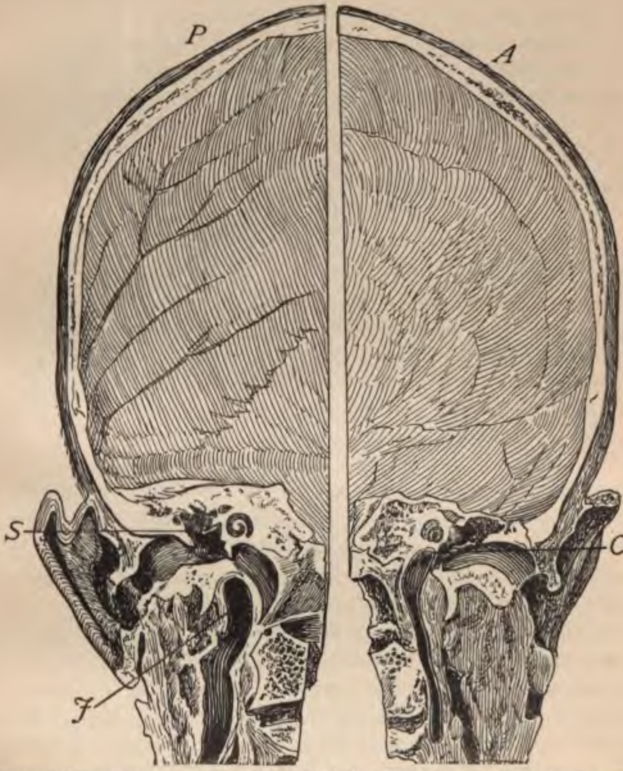
FIG. 91.



Allport's Middle-ear Forceps.

In operating upon the anterior or inferior portion of the tympanum the position of the carotid artery and the bulb of the jugular vein should be borne in mind (Figs. 92, 99, 113). Ordinarily the jugular vein is defended by bone of sufficient thickness to prevent injury to the vessel, but sometimes this bone is lacking, and under such circumstances the vein lies just below the tympanic mucous membrane. Several cases of injury to the jugular vein during intra-tympanic operations have occurred, but without fatal results. Although no cases of injury to the carotid artery during operations upon the middle ear are known, yet the artery lies dangerously near anteriorly, and it is well to use a probe-pointed knife when operating in this locality. Hemorrhage from this portion of the artery as the result of necrosis has invariably sooner or later terminated fatally, even after ligation of the internal carotid artery in the neck.

FIG. 92.



Vertical Frontal Section through the Middle of the External Meatus: *A*, anterior; *P*, posterior portion of the specimen; *C*, carotid artery; *J*, internal jugular vein. The carotid is separated from the anterior median wall of the tympanum by an extremely thin septum of bone, which in numerous instances is entirely lacking, so that the vessel might be wounded by the knife of a heedless operator during an intra-tympanic operation. The bulb of the jugular vein is separated from the cavity of the tympanum by the mucous membrane and a thin septum of bone that is sometimes lacking. The bulb of the jugular vein has been wounded during the operation of paracentesis. In the specimen the drum-head, malleus, and incus have disappeared as the result, probably, of chronic suppuration (from a photograph of a dried preparation in the author's collection).

After the removal of the malleus and incus, if it be deemed necessary in order to gain better access to the attic for after-treatment, the lateral wall of the attic may be removed by means of the curette (Fig. 109). This procedure is somewhat more difficult than the Stacke operation described below, but can be done without displacing the auricle (a source of dread to many patients), and yields very satisfactory results.

The after-treatment of the operation for the removal of the remains of the drum-head, malleus, and incus in suppurative cases is similar to that already described after operation in catarrhal cases.

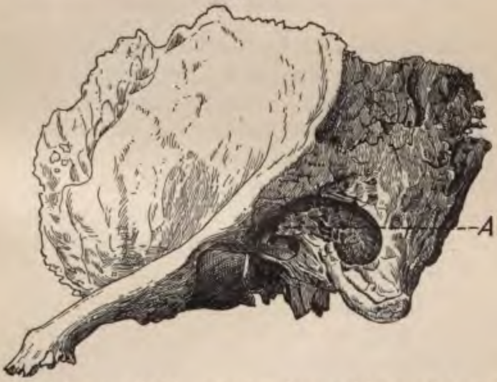
What are the indications for Stacke's operation of chiselling away the posterior superior wall of the meatus and laying free the tympanic cavity and, if necessary, the antrum?

Caries of the walls of the tympanic cavity and ossicula; excessive growth of granulations in the tympanic cavity, with cholesteatomatous formation in the attic; if suppuration continues for a long time in spite of careful after-treatment following a mastoid operation according to Schwartze's method, or if dangerous symptoms arise during the after-treatment.

Describe the operation.

An incision is made to the bone, from the tip of the mastoid, around the attachment of the auricle to a point above the tragus. The periosteum is then pushed forward with the anterior flap until the superior and posterior margins of the osseous canal are brought clearly into view. The cartilaginous canal and as much of the periosteum as possible are now separated from the bony canal by means of a small elevator. An incision is made through the loosened tissues as close to the drum-head as possible, and by traction forward upon the auricle the funnel-shaped mass is pulled out of the bony canal, exposing the tympanic structures clearly to view. By means of the mallet, gouge, and curette the upper posterior wall of the inner meatus is removed, layer by layer, until the attic is fully exposed to view. If the malleus and incus are present, they should then be removed with the forceps, care being exercised at every stage of the operation to protect the stapes. The chiselling should be continued until the curette no longer catches upon an overhanging ledge of bone while being drawn from the meatus. If it is thought desirable to open the antrum, the chiselling should be continued posteriorly until this cavity is freely exposed to view (Figs. 93, 94). At all stages of the operation the curette (Fig. 109) will be found a most valuable aid to the removal of the sharp edge of bone overhanging the canal. Its curved tip should be cautiously introduced into the tympanum beneath the overhanging bone, which is somewhat rapidly cut away, not by drawing the instrument outward, but by rotating it in such a manner that the bone is cut alternately by the sharp anterior and posterior edges of the cup, the curved tip of the curette in the mean while preventing the instrument from becoming displaced. In order to afford a firm grasp upon the instrument while executing this manœuvre, the handle of the instrument between the cups is made very broad and roughened.

FIG. 93.



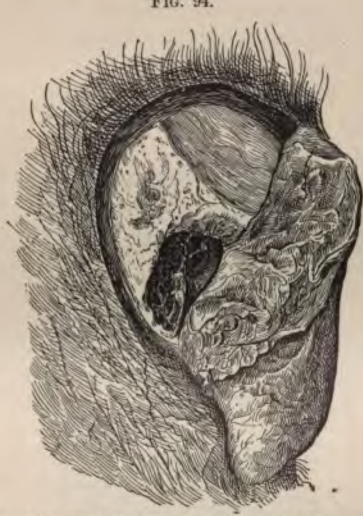
Adult Temporal Bone, with the upper and part of the posterior wall of the meatus chiselled away so as to form one large cavity of the meatus, tympanum, and antrum: *A*, hard ridge of bone surrounding the Fallopian canal. The amount of bone removed by the chisel, while somewhat smaller than that figured in some of the text-books, is probably as large as is safe in a large proportion of cases (from a photograph of a preparation in the author's collection).

After all affected parts have been removed, the attic and, if necessary, the antrum fully exposed, the soft parts are replaced, the external incision sutured, and a drainage-tube passed into the bony canal, completely filling its lumen and thus preventing displacement.

When the antrum has been freely opened it is customary to incise the soft parts longitudinally and press the flaps thus formed backward into the cavity. In this manner a cutaneous lining for the antrum may be secured.

In some instances, where the attic is known to be occupied by pulpy granulations and cholesteatomatous masses, it is well to perform Stacke's operation after opening the mastoid antrum through the cortex of the mastoid according to Schwartze's method, subsequently to be described.

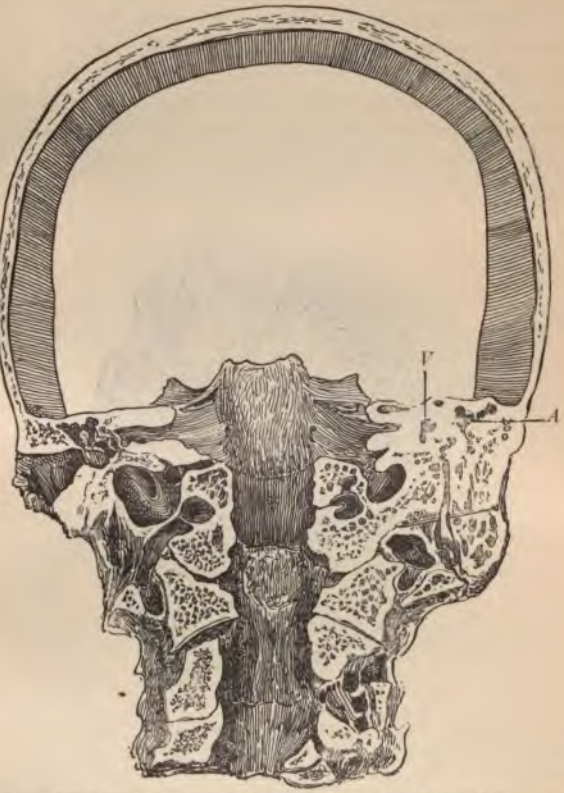
FIG. 94.



Küster's Operation. The auricle is turned forward, the cartilaginous meatus detached, and the bony wall of the meatus chiselled away as in the preceding figure. The malleus and incus still remain in position, but are somewhat dimly seen in the figure (from a photograph of a dried preparation in the author's collection).

Küster, after opening the mastoid antrum by Schwartze's method, chisels away the intervening bone between the meatus and the artificial opening through the cortex of the mastoid. The disadvantage of this method is that it is somewhat slow and tedious, and that the removal of the outer wall of the attic, being left until the last, is

FIG. 95.



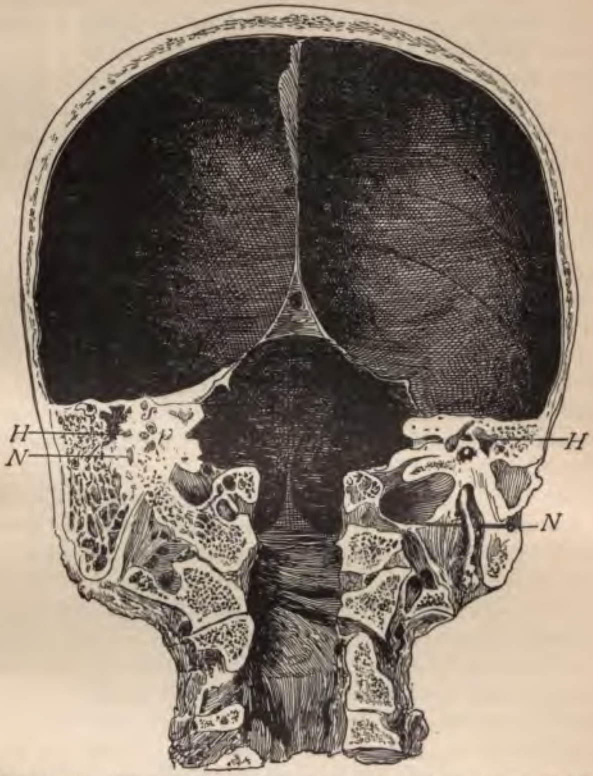
Vertical Frontal Section through the Skull, anterior portion of the specimen. The saw has passed through the spina on the right side and laid open the aquæductus Fallopii through its entire vertical portion, showing the facial nerve, under which a pin has been passed. It should be observed that the nerve lies nearly vertical in this part of its course, while above and *external* to it is an opening into the most external portion of the horizontal semicircular canal. The anterior part of the antrum, *A*, has been opened, and also the vestibule, *V*, and the superior semicircular canal. On the left side the saw has passed through the posterior portion of the external and internal meatus (from a dried preparation in the author's collection).

apt to be slighted and neglected, although the most important part of the operation, so far as accomplishing the result of affecting ultimate cessation of chronic suppuration is concerned.

Most operators prefer to use for opening the mastoid antrum, either by Schwartze's or Stacke's method, a chisel and mallet, Schwartze's set of chisels and gouges (Fig. 110) being ordinarily employed for this purpose; but Randall dispenses entirely with the mallet, and uses hand-gouges of two sizes (Fig. 108). With these instruments, partly by thrusting the gouge forward and partly by a rotary motion, it is possible to penetrate the hardest bone with surprising facility and quickness. There is, however, more danger of the instrument slipping than when the mallet and chisel are skilfully employed. The advantage claimed for the hand-gouges is that there is less concussion of the intracranial structures than when a mallet is employed. In using a mallet it is important that the blows should be quick and light rather than heavy, and delivered in such a direction, if possible, that their force will not be transmitted to the brain.

When chiselling away the posterior superior wall of the meatus and opening the attic, the topographical relation of the posterior wall of the meatus to the descending portion of the facial nerve should be borne in mind. The aquæductus Fallopii does not extend downward and outward, as stated in most text-books upon anatomy, but directly downward (Figs. 95, 96). Indeed, if two probes be inserted into the facial canals through the stylo-mastoid foramina of any skull, it will be found that the probes are parallel, or in some instances incline somewhat toward each other. Although the course of the descending portion of the facial nerve is vertical, yet, because of the upward and outward inclination of the drum-head, the facial nerve approaches the annulus to within 1 or 2 millimetres posteriorly, on a level with the centre of the meatus; hence, if the whole of the posterior wall be removed, it will be impossible to avoid injuring the facial nerve. The Fallopian canal is contained in a hard mass of bone (Figs. 112, 113), and hence is protected to a certain extent from injury at the hands of careful operators. The student should study the topographical relation of the structures involved in operations upon the middle ear by preparing a large number of frontal, sagittal and horizontal sections of the ear. Such sections should be made,

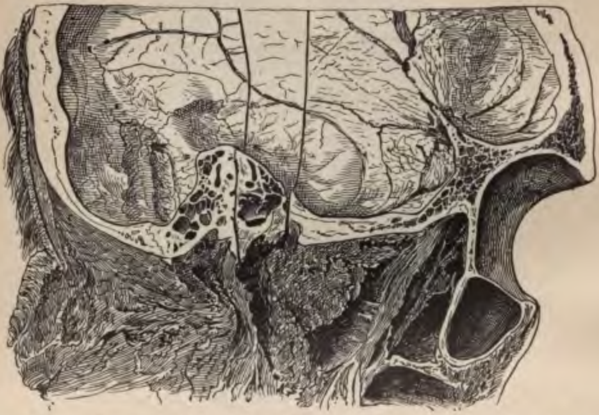
FIG. 96.



Vertical Section through the Skull, posterior portion of the same specimen as Fig. 95. On the left side the saw has passed just anterior to the aquæductus Fallopii, and a pin has been passed under the facial nerve, *N*, at its exit from the stylomastoid foramen. Above is seen an opening made into the commencement of the vertical portion of the facial canal. Still higher up is a portion of the horizontal semicircular canal laid open and occupying a position somewhat *lateral* to the facial nerve and median to the aditus. On the right side the section has passed through the anterior part of the antrum, and is posterior to the facial canal and has opened the horizontal semicircular canal at its most external part (from a dried preparation in the author's collection).

not through a separated temporal bone, but while the bone is still in position in the skull. Injected heads sawn in half through the sagittal suture, and mummified by exposure upon the roof of a house for a few weeks during the summer, are very suitable for making such sections. After the sections are made the parts may be cleansed and bleached by spraying them with an atomizer containing a weak solution of peroxide of hydrogen rendered slightly alkaline by the addition of liquor potassa. After subsequent drying the soft parts should be preserved by applying to them several coats of bleached shellac varnish, which may be made to assume any color required to render the structure more natural in appearance by the addition of one of the aniline dyes. Each coat of varnish is allowed to soak well into the soft tissues in order to preserve them.

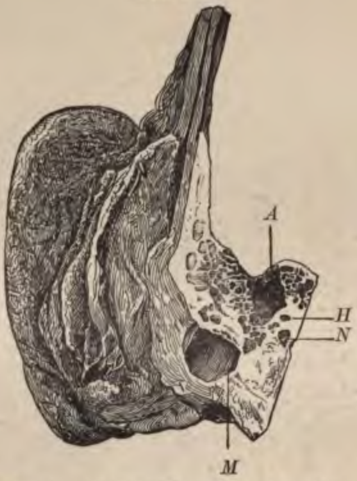
FIG. 97.



Vertical Sagittal Section through the Tympanum; median aspect of the lateral portion of the specimen. The lower part of the membrana tympani is cut away by the saw, and above the drum-head inclines outward at an angle of 140° with the upper wall of the meatus. The malleus-handle and the malleo-incudal articulation, as well as the descending process of the incus, are visible. The section passes through the canal for the tensor tympani muscle, so that the trochlea and tendon are shown. Above the tympanum, portions of each of the semicircular canals are visible (from a dried preparation in the author's cabinet).

The most useful sections for purposes of study are a vertical, frontal section through the spina supra-meatum (Figs. 98, 102), a vertical sagittal section through the floor of the tympanum (Fig. 97), a horizontal section through the roof of the meatus (Fig. 99), and a section parallel to the inner wall of the tympanum (Figs. 112, 113). Besides making the sections through the middle ear, the student would do well to operate many times upon the cadaver before attempting any serious operation involving the middle ear of a patient.

FIG. 98.



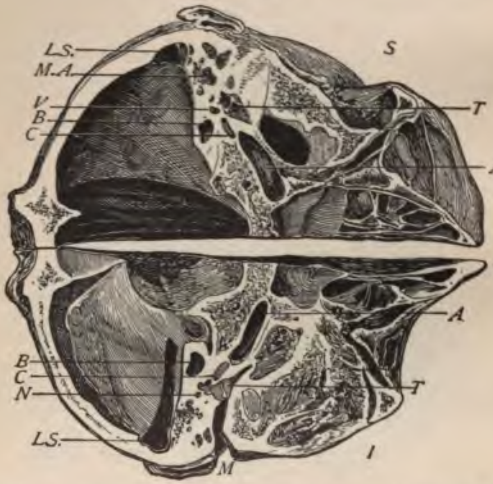
Posterior Surface of the Portion of the Ear removed by the two vertical frontal saw-cuts seen in the preceding figure. The external bony meatus has been laid open only at its most external portion. Above, the saw has passed through the aditus and posterior to the facial canal: *A*, aditus; *H*, horizontal semicircular canal; *M*, meatus; *N*, facial nerve.

MASTOIDITIS.

Describe the external and middle ear of a new-born child.

At birth the external auditory meatus is essentially a closed canal. The drum-head lies nearly in the same plane with the upper wall of the meatus (Fig. 100), and forms such an extremely acute angle with the lower wall that the upper and lower walls are practically in contact except for the *vernix caseosa* (greasy paste), which, covering the entire body of the child at birth, also extends into the auditory canal, completely blocking it up so that no air can enter.

FIG. 99.

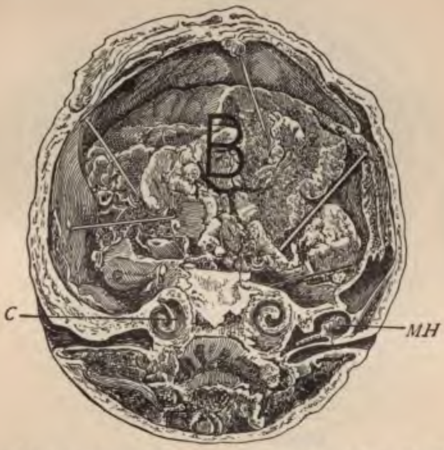


Horizontal Section through the Roof of the External Meatus: *I*, inferior portion; *S*, superior portion of the specimen; *M*, external auditory meatus; *T*, tympanum; *M. A.*, mastoid antrum; *A*, carotid artery; *L. S.*, lateral sinus; *B*, bulb of the jugular vein; *N*, facial nerve. In the lower half of the specimen is the handle and short process of the malleus, the saw having passed through the neck of the bonelet. The membrane slopes obliquely forward at an angle of 55° with the axis of the meatus, and outward at an angle of 140° with the roof of the meatus. The section passes through the oval window, so that the cavity of the vestibule (*V*), as well as the cochlea (*C*), is shown in the upper half of the specimen. Here also is to be seen the malleus-head, the incus, the attic, and the mastoid antrum. The stapes has been removed by the saw. The bulb (*B*) of the jugular vein extends upward farther than in most specimens.

The drum-head is covered by extremely thick epidermis, while the cavity of the tympanum is usually completely filled with its own mucous membrane, which, enormously hypertrophied at all parts of the tympanum, is thickest upon the inner wall, where it is markedly hyperæmic and jelly-like in appearance, in marked contrast to that of adult life, which upon the promontory is thin and nearly bloodless in appearance.

The offspring of the human race is hence, like that of many of the lower animals, born into the world almost completely deaf. At birth or soon afterward the tympanum becomes a cavity containing air. The thick epidermis of the outer layer of the drum-head is exfoliated, and the mucous cushions within the tympanum disappear with greater or less rapidity.

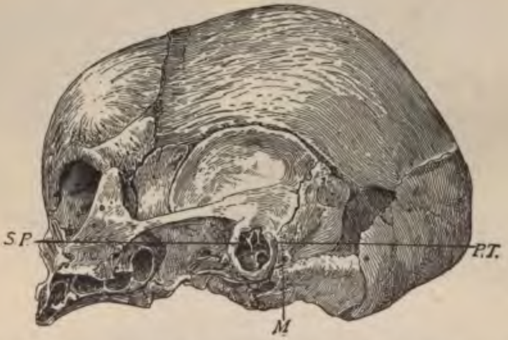
FIG. 100.



Vertical Frontal Section through the External Auditory Canals of a Fœtus stillborn at the end of the seventh month, anterior portion of the head. The external auditory canals slope somewhat downward, and the membrana tympani are nearly horizontal. The lower wall of each canal is in contact with the upper except for the presence of a small quantity of the same cheesy material (*vernix caseosa*) that covered the rest of the skin of the fœtus. The tympanum is completely filled by the ossicles and its own mucous membrane, which is much thicker than that of the adult. The malleus is in position in the right ear, but has been removed by the saw from the left. *B*, brain; *M. H*, head of the malleus; *C*, cochlea of the left ear (from a specimen in the author's collection).

The osseous canal of the adult is represented in infants by the annulus tympanicus (*P T*, Fig. 101), one of the three separate bones comprising the temporal, and forming by gradual development the vaginal process of the auditory meatus of the adult. The rest of the canal is composed largely of embryonic tissues covered by skin, and measures from the tragus to the umbo usually about 30 mm., while that of the adult measures from 31 to 35 mm. between the same structures. Because of the nearly horizontal position of the drum-head, Shrapnell's membrane (Fig. 4) lies so near the orifice of the canal that when greatly swollen it almost protrudes, resembling a polypus somewhat in appearance; indeed, it has been mistaken for a polypus, and removed, together with the malleus and incus. To examine the drum-head of young children it is necessary to draw the lobule downward in order to detach the lower from the upper wall of the meatus. The ossicles, tympanum, and mastoid antrum are nearly as large as those of an adult, but are superficially situated, and in opening a mastoid abscess in an infant, therefore, it is not unusual for the probe to pass through the antrum into the attic for a distance of nearly an inch. The mastoid antrum of young children is situated medianly from the posterior tubercle of

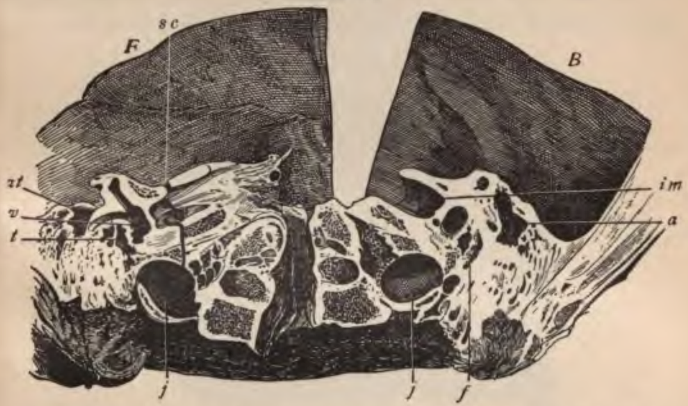
FIG. 101.



Left Half of the Skull of a Stillborn Infant, showing the inferior surface of the petrous bone, the annulus tympanicus, the ossicles, the tympanum, and the mastoid process. The ossicles, the tympanum, and the mastoid antrum are nearly as large as those of an adult. *M*, mastoid process; *S. P*, short process of the malleus; *P. T*, posterior tubercle of the annulus tympanicus (from a specimen in the author's collection).

the annulus (Fig. 101), and this elevation should be searched for as a landmark when operating upon the temporal bone of infants. It should also be borne in mind that the mastoid-squamous suture is not ossified at birth, and frequently presents large dehiscences during childhood, so that when making the primary incision for a mastoid operation upon a young child the point of the knife should not be pressed with force against the bone, or it may enter one of these dehiscences and penetrate the cranial cavity. The incision should be made with due deliberation until the bone is exposed in the whole length of the incision, and the periosteum pushed forward with great care and gentleness. Unnecessary curetting within the mastoid antrum and attic should also be avoided, as the petro-squamous suture remains open for some time after birth, and a process from

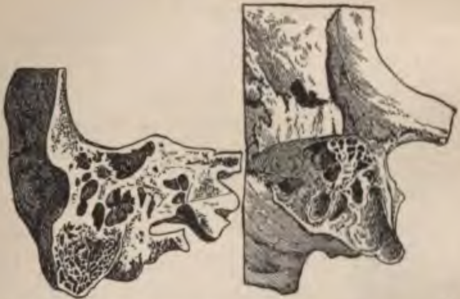
FIG. 102.



Vertical Frontal Section through the Spina of a Child eight years old: *F*, anterior, *B*, posterior portion of the specimen; *at*, attic with tegmen removed; *v*, vestibule with horizontal and superior semicircular canals laid open; *t*, tympanum; *j*, jugular vein; *f*, aquæductus Fallopii; *a*, mastoid antrum; *im*, internal meatus; *sc*, saw-cut through the centre of the modiolus, at right angles to the tubo-tympanic axis, in order to lay open the cochlea. A section of this kind through the modiolus is commended to students as showing the topography of the anterior portion of the tympanum in relation to the articulation of the lower jaw and the carotid artery (from a dry preparation in the author's collection).

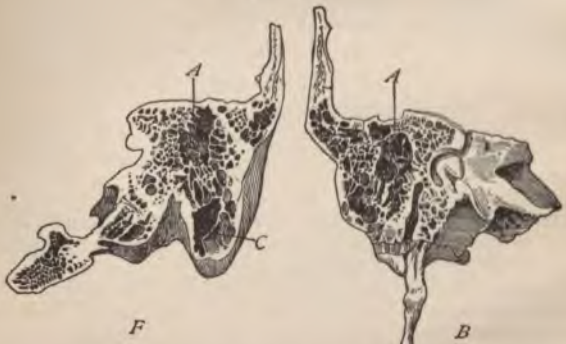
the dura not unfrequently extends downward to unite with the mucous membrane of the middle ear.

FIG. 103.



Large-celled Pneumatic Processes: the tip of the one to the left is diploëtic (from specimens in the author's cabinet).

FIG. 104.

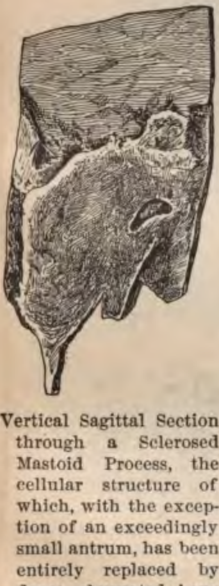


Frontal Section through the Spina of a Mastoid Process consisting almost entirely of small pneumatic cells: *F*, anterior, *B*, posterior portion of the specimen; *A*, antrum; *C*, large cell at the tip of the process; the semicircular canals and the aquæductus Fallopii have been laid open after the section was made (from a specimen in the author's cabinet).

Describe the adult mastoid process.

At birth the mastoid process consists of a small flattened tuberosity containing but one cell, the mastoid antrum. At the age of eight years the child's mastoid generally contains numerous other pneumatic spaces radiating from the antrum, and its topographical relations are well shown in Figure 101. At puberty the mastoid has become a distinct prominence, conical in shape, with its apex downward. It may or may not contain pneumatic cells in addition to the antrum; in fact, there are four distinct types of mastoid structure:

FIG. 105.



Vertical Sagittal Section through a Sclerosed Mastoid Process, the cellular structure of which, with the exception of an exceedingly small antrum, has been entirely replaced by dense eburnated bone (from a specimen in the author's cabinet).

1. The pneumatic, in which the whole mastoid process is composed of pneumatic spaces communicating with each other and with the antrum, and lined with a continuation of the mucous membrane of the middle ear. The pneumatic spaces may be large (Fig. 103) or small (Fig. 104). If the pneumatic spaces are small, one comparatively large cell is generally found at the mastoid tip.

2. The diploëtic, the entire bone containing no air-spaces, but composed of diploëtic tissue.

3. The pneumo-diploëtic, in which pneumatic spaces and diploëtic tissue are both found (Fig. 103).

4. The sclerosed, in which the entire bone is composed of compact bone often as hard as a tooth (Fig. 105).

What is the pathological importance of these types of mastoid formation?

Pathologically and surgically, the structure of the mastoid process is of the utmost importance. In the pneumatic type of mastoid with large cells, pus from the antrum readily finds its way to the lateral surface, but in the diploëtic, and more especially in the sclerosed type, there is greater danger of pus burrowing its way into the cranial cavity. The difficulties of the mastoid operation are also greatly increased by the compactness and hardness of the bone. Where a large cell is present at the mastoid tip with a thin median wall, pus is more likely to find its way into the digastric fossa than to penetrate the thicker external cortex.

What is the etiology of mastoiditis?

It is doubtful if primary inflammation of the mastoid ever occurs except as the result of syphilis or tuberculosis, the disease being in almost every instance the result of an extension, by continuity of structure, of inflammation from the tympanum. Politzer states that in every post-mortem that he made of chronic suppuration of the middle ear the mastoid cells were diseased. Mastoiditis, then, is generally the sequence of acute inflammation of the tympanum or of chronic suppuration of the middle ear. In rare instances suppurative inflammation of the deeper portion of the auditory canal may extend under the periosteum until pus appears upon the external surface of the mastoid beneath the periosteum; or infection may be transmitted by means of the veins which traverse canals passing from the meatus into the mastoid cells.

What is the pathology of mastoiditis?

The most acute cases, starting in an inflammation of the mucous membrane of the middle ear and mastoid antrum, and extending to that lining the mastoid cells, run a most rapid course, but a few days elapsing between the onset of the disease and the operative opening of the mastoid necessary for the removal of pus and necrotic bone. In such cases the abscess-cavity does not usually communicate with the mastoid antrum, but it is generally superficially situated just beneath the cortex of that bone. The middle-ear symptoms, however, may have subsided and for weeks all signs of mastoiditis have disappeared, except perhaps slight tenderness on deep pressure over the bone, with occasional slight shooting pain through it, when a fluctuating swelling appears over the mastoid bone, the digastric fossæ, or in the deep tissues of the neck, indicating that spontaneous perforation of the cortex of the mastoid bone has occurred and released the contained pus.

The changes that occur in slowly progressive inflammation of the mastoid cells are of two kinds. Sometimes a limited necrosis is produced, the surrounding tissues being thickened and consolidated to the extent of entirely obliterating the pneumatic spaces. Where the active inflammation has subsided without suppuration *hyper-*

ostosis, or consolidation of the mastoid, may occur without necrosis or caries.

In most chronic cases the mastoid antrum becomes filled with cholesteatomatous masses, thus isolating the mastoid cells from the tympanic cavity. *Active mastoid complications* during chronic suppuration of the middle ear frequently manifest themselves during an acute exacerbation of the middle-ear disease, with the result of producing an acute inflammation of a limited area of bone in the centre of a sclerosed mastoid.

Caries or necrosis of the mastoid may extend inward and involve the lateral sinus, producing phlebitis, thrombosis, emboli, and their consequences. The middle fossa of the skull may also be penetrated and an abscess produced beneath the dura mater, a local pachymeningitis preventing further extension of the disease; or meningitis, both at the base and convexity of the brain, or brain-abscess, may occur.

What are the symptoms of mastoiditis?

In acute cases the first symptom is intense pain, involving the mastoid and often the whole side of the head. There are tenderness on pressure over the mastoid, fever, and in most cases swelling and congestion of the upper posterior part of the meatus. In the more chronic form of the disease the patient is sometimes remarkably free from pain, almost the first symptom to which the surgeon's attention is called being congestion of Shrapnell's membrane, with swelling at the upper posterior part of the meatus, over the mastoid, or of the neck below the ear. Deep fluctuation can be made out at each of these points in some cases.

It is often difficult to make an early diagnosis of commencing otic meningitis. The chief symptom at the beginning of brain complications is usually headache, which, at first intermittent, soon becomes constant and increases in severity. Accompanying the headache there are restlessness, insomnia, occasional vomiting, and dulness of the intellect. If the eye be examined with the ophthalmoscope, commencing optic neuritis will be discovered. In children coma frequently occurs. Dilatation of the pupil, paralysis of the accommodation, strabismus, ptosis or paralysis of other muscles of the body, may sometimes be present as the result of brain-abscess. The symptoms of phlebitis of the lateral sinus are chills, followed by high temperature. The circulation soon becomes checked as the result of the formation of a thrombus, which may in rare cases extend downward and backward to the torcular Herophili or into the jugular vein, where it may be felt as a hard cord, or into the mastoid vein, producing œdema and inflammation of the posterior portion of the neck. The formation of a thrombus is usually followed by fatal results.

What is the treatment of mastoiditis?

When there is congestion of the posterior portion of Shrapnell's membrane and swelling of the neighboring tissues of the meatus a free incision through Shrapnell's membrane and the swollen tissue will sometimes abort the attack. One or more leeches, however, should also be used over the mastoid bone, or Wild's incision should be made. This consists of a semicircular cut just back of the auricle from a point over the middle of the meatus downward nearly to the tip of the mastoid process. Care should be exercised that the incision extends through the periosteum to the bone. Wild's incision probably cannot be made too early during an attack of mastoiditis, but it should be viewed as possibly only the first step in other operative procedures that may ultimately become necessary. The bleeding often gives relief from pain even when no pus is found, while the wound acts as a counter-irritant or revulsive until healed. If, notwithstanding these procedures, pain and high temperature persist, it will be necessary to produce an opening through the mastoid to the antrum in order to secure prompt removal of the products of inflammation.

What is the history of operations upon the mastoid process?

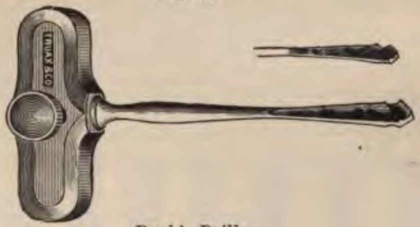
The operation of opening the mastoid cells was first proposed by Riolanus about 1600. Fifty years later the performance of the operation was opposed by Sir Thomas Browne. Trephining the mastoid for the removal of the products of inflammation was first done by Jean Louis Petit, a distinguished French surgeon who died in 1750. The Prussian military surgeon, Jasser, trephined the mastoid process in 1776. His earlier operations were done for the release of the products of inflammation, and were highly successful, but he and his successors soon lost sight of the true indications for the operation, which soon became very popular and was frequently performed for the relief of deafness and tinnitus. Disastrous and even fatal results were somewhat numerous, and finally culminated in the death of Baron von Berger, physician to the king of Denmark. Berger had suffered for some time from noises in the ears and gradually increasing deafness without suppuration. Perforation of the mastoid cells and the injection of an astringent solution were soon followed by fever and delirium which ended in death on the eleventh day. At the post-mortem, the mastoid was found to be almost rudimentary and the trephine had entered the brain. Death resulted from purulent meningitis. Because of the prostitution of this most useful operation, trephining the mastoid fell into disrepute, and for nearly a century was referred to in medical literature as one of the curiosities of surgery rather than a justifiable procedure. The status of the operation was re-established by the writings of Forget in 1849 and those of Follin and von Troeltsch in 1859. Troeltsch cut through swollen tissues down to the mastoid to prevent necrosis; and if there was evidence of deeper seated disease, he penetrated the bone behind and parallel to the meatus by means of a blunt probe, and when the cortex was thick and hard he used a small trephine. To Schwartze is due the credit of developing the mastoid operation as performed at the present time. Schwartze's first series of 100 cases published in 1883 gave a death-rate of 20 per cent., a mortality that has been greatly decreased as the result of performing the operation earlier in the history of the disease, before intracranial complications have had time to develop.

Describe the operation of opening the mastoid.

The instruments required for the convenient performance of the operation are a scalpel, five or six hæmostats, a pair of broad retractors, Allport's dilator (Fig. 111), a pair of bone-gnawing forceps (Fig. 107), two bone-gouges (Fig. 108), two bone-curettes (Fig. 109), a steel grooved director, a silver probe, mallet and chisels.

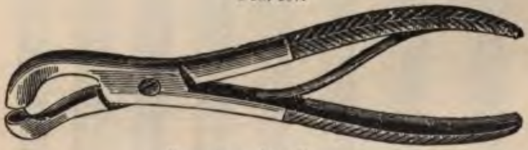
While the operation of opening the mastoid is generally performed for liberating the contents of a septic cavity, it should be done under antiseptic precautions. The instruments should be sterilized by boiling them in a 2 per cent. soda solution, and the hands of the operator and those of his assistants disinfected in the usual manner. In most instances it is desirable to shave off the patient's hair for a considerable distance above and behind the ear to be operated upon.

FIG. 106.



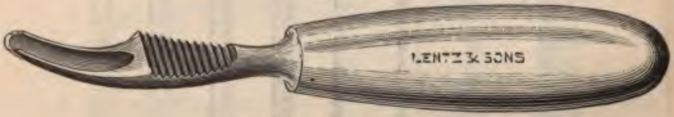
Buck's Drills.

FIG. 107.



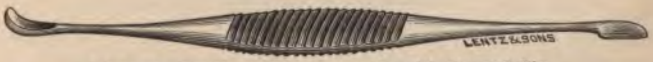
Bone-gnawing Forceps.

FIG. 108.



Randall's Hand-gouge.

FIG. 109.

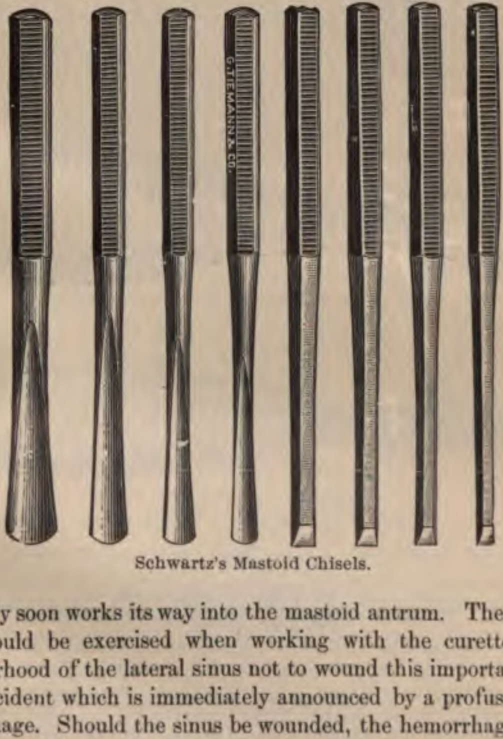


Gleason's Double-end Bone-curette with Curved Tip.

The skin covering the field of operation should be disinfected in the usual manner, and the auditory canal thoroughly cleansed and afterward syringed with a warm bichloride solution.

If the drum-head is not perforated, it is best, in most instances, to preface the operation by an incision through the posterior part of the membrane toward the mastoid antrum. Wild's incision should then be made in the manner already described, and the surface of the mastoid carefully searched by means of a probe for a sinus or softened bone, which, if found, should be broken through by means of the hand-gouge (Fig. 108). All softened bone, pulpy granulations, and cheesy pus should be removed with the curette (Fig. 109), which ordinarily soon works its way into the mastoid antrum. The greatest care should be exercised when working with the curette in the neighborhood of the lateral sinus not to wound this important vessel —an accident which is immediately announced by a profuse venous hemorrhage. Should the sinus be wounded, the hemorrhage should be controlled by packing the wound with iodoform gauze, which after the lapse of a few moments can usually be removed without a

FIG. 110.

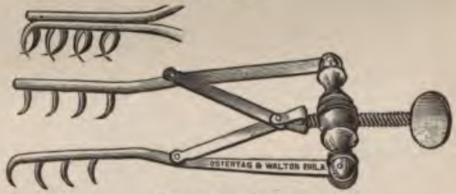

G. TIEMANN & CO.

Schwartz's Mastoid Chisels.

recurrence of the hemorrhage. Further operative procedures with the curette should under these circumstances be attempted only with the utmost caution. Indeed, it is best in many of such cases to simply repack the wound with iodoform gauze and apply a bandage. The possibility of injuring the facial nerve or opening the external semicircular canal should also be borne in mind.

After all the softened bone has been removed with the curette, all overhanging edges of bone should be removed by the *rongeur* or chisel, and also the partition of bone between the auditory meatus and the wound if it be thin. In all cases where a cholesteatoma is encountered it is advisable to turn the auricle forward as already described and remove a sufficient quantity of bone to form one large cavity of the meatus, tympanum and antrum according to the method of Stacke or Küster (Figs. 93 and 94). When executing either of these operations it is possible to wound the facial nerve as it crosses the tympanum. To avoid the possibility of this occurring it is advisable to remove only the upper portion of the posterior wall in the deeper portion of the meatus and thus avoid the compact mass of bone containing the facial nerve (Fig. 112). The horizontal semicircular canal, although it is situated external to the facial nerve, lies too high up to be in danger of being opened. If the facial be not too greatly injured, recovery from the ensuing facial paralysis is probable under the use of the galvanic current.

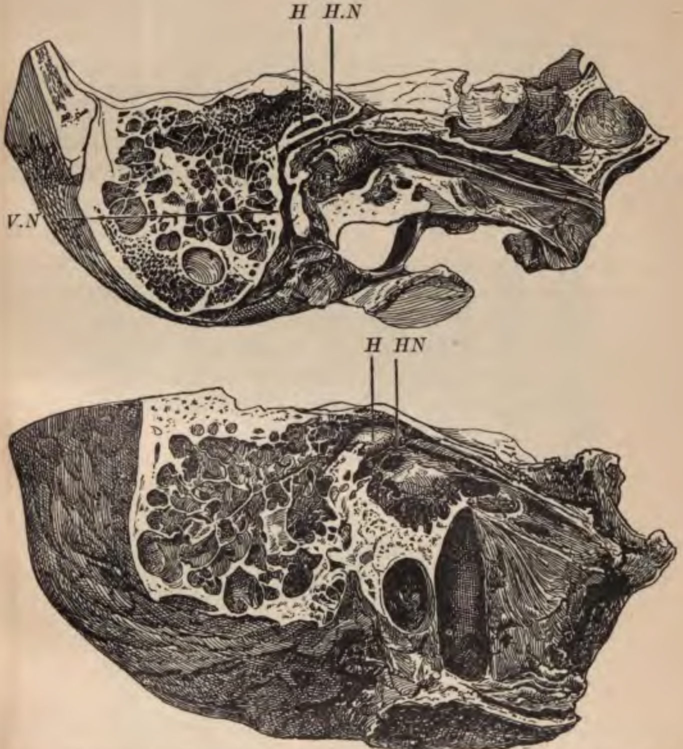
FIG. 111.



Allport's Dilator.

In diploëtic and compact mastoid bones the lateral sinus sometimes occupies a position more anterior and superficial than is normally the case. In the bone shown in Fig. 113 it would be impossible to open the antrum by the usual method, as the sinus would be en-

FIG. 112.

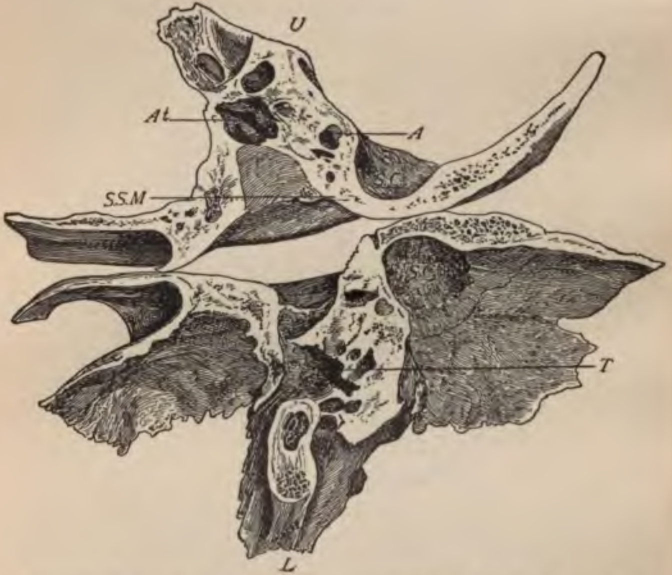


Sections through the Tympanum parallel to its Inner Wall; median aspect of the specimens: *H*, horizontal semicircular canal; *H. N*, horizontal portion of aquæductus Fallopii; *V. N*, vertical portion. In the upper specimen the section is somewhat more median than in the lower, in order to open the horizontal semicircular canal and the aquæductus Fallopii. It will be observed that in the lower specimen the tubercle, *H*, containing the semicircular canal is more lateral than the hard ridges of bone below it, *HN*, containing the facial canal. In the upper specimen the stapes is in the oval window, and the topography of the inner wall of the tympanum, the aditus, and the mastoid antrum is well shown in both specimens (from specimens in the author's cabinet).

countered after the first few strokes of the chisel. In rare instances the sinus lies just beneath the skin and is liable to be wounded by the knife in making the primary incision.

If a mastoid operation does not follow Wild's incision previously performed during the primary treatment of the disease, it is advisable to make a free section through the skin to the bone from the tip of the mastoid, close to the insertion of the auricle and upward to a point just above the helix; the periosteum should then be rapidly separated from the bone by pulling it forward with the

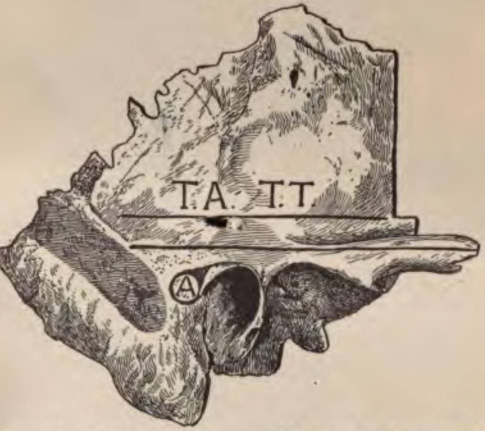
FIG. 113.



Horizontal Section through a Right Temporal Bone below the Spina, showing an extreme anterior and superficial position of the sigmoid sulcus, thus bringing the lateral sinus within 1.5 mm. of the bony surface at the operating point and rendering the ordinary mastoid operation impossible. At a position somewhat above the operating point the sulcus is less than one-half mm. from the bony surface. *U*, upper, *L*, lower portion of the specimen; *S.C*, sigmoid sulcus; *T*, tympanum; *At*, attic; *A*, small antrum; *S.S.M*, spina supra-meatum (from a specimen in the author's cabinet).

curette until the spina supra-meatum (Fig. 114) is brought into view, this structure being carefully preserved during the subsequent procedures of the operation to serve as a landmark. Instead of seizing the arteries with hæmostats, it is often more convenient to insert two Allport's dilators (Fig. 111) and thus stretch the large skin-wound wide open and afford ready access to the bone. All hemorrhage ordinarily ceases after the insertion of the dilators.

FIG. 114.



Lateral Surface of a Right Adult Temporal Bone, showing superficial landmarks. The shadow indicates the position of the lateral sinus. *A*, antrum; immediately in front is a well-developed spina supra-meatum at the posterior superior border of the meatus; *T.A.*, *T.T.*, upper surface of the tegmen antri and tegmen tympani. In some specimens the middle cerebral fossa extends as low down as the dark line immediately above the meatus, and hence chiselling cannot be carried above the level of this line without danger of entering the cranial cavity (from a specimen in the author's cabinet).

If no softened spot or sinus is found upon the surface of the mastoid bone after completing the primary incision, it will be necessary to make an opening by means of the mallet and chisel, the hand bone-gouge, or Buck's perforator. Randall depends entirely upon the hand gouge, employing two sizes of instruments (Fig. 106), with which he penetrates the hardest bone with a great celerity and ease;

whilst Blake prefers to penetrate at least the cortex of the mastoid with Buck's perforator and enlarge the opening with a mallet and gouge. Most operators, however, depend largely upon the mallet and chisel, removing toward the close of the operation all overhanging edges of the cortex with bone-gnawing forceps (Fig. 106).

The opening in the cortex should be made just below and behind the spina, and should extend inward and slightly upward parallel to the bony meatus until pneumatic spaces are encountered or the antrum penetrated. In some cases the bone is so dense that no pneumatic spaces or softened bone is encountered until the neighborhood of the antrum is reached. Even this cavity may be small and easily overlooked. If the antrum is not encountered at a depth of 15 mm., or three-fifths of an inch, the operator should proceed with great caution to avoid injuring the facial canal or entering the cranial cavity. In some instances where the drum-head and ossicles are partially destroyed a silver probe with its end bent at a right angle may be carried through the canal into the vault of the tympanum and held in such a position as to serve as a guide. If the chiselling be continued in the right direction, there will be little danger of wounding any important structure before the probe is encountered. Even though no pus be encountered, but only softened bone in the neighborhood of the antrum, the relief of all mastoid symptoms usually follows the operation.

When pneumatic spaces are encountered, the opening made by the chisel should be enlarged, if necessary, with the rongeur, and the walls of the pneumatic spaces broken down, if diseased, with the curette in a direction to reach the mastoid antrum, free communication with which should be established, if necessary, as well as the removal of all carious bone, cholesteatomatous masses, and pulpy granulations. Politzer states that it is undesirable to establish a communication between an abscess-cavity and the mastoid antrum when the latter is surrounded by healthy bone, as is generally the case in acute suppurative mastoiditis.

In the event of pus having gravitated into the tissues of the neck from an opening upon the inner surface of the mastoid, the incision through the skin should be carried sufficiently low down along the posterior border of the sterno cleido-mastoid to permit of efficient drainage and access to the bone from below as well as from above.

After the operation is completed the auditory meatus and wound should be irrigated freely with warm sterilized water. It is not advisable to use solutions of corrosive sublimate for this purpose while the patient is under ether, as the fluid may run through the Eustachian tube into the throat and an unknown quantity be swallowed. If the wound communicates freely with the tympanic cavity, fluid syringed into the wound will flow out of the meatus, but should this not be the case free communication will probably be established within a few days following the operation. If necessary one or more sutures should be used to hold the auricle in position, the wound and auditory canal lightly packed with iodoform-gauze, and a roller bandage applied over sterilized gauze and cotton.

Twenty-four hours after the operation the dressing should be removed from the wound and the parts carefully inspected. The nose and naso-pharynx should then be cleansed with the spray from an atomizer containing an alkaline antiseptic wash, and the middle ear inflated according to Politzer's method in order to drive secretions from the middle ear into the meatus and wound. The parts should then be thoroughly douched with a one to one-thousand bichloride solution, or cleansed with a spray of a solution of peroxide of hydrogen, the wound again packed lightly with iodoform gauze, and the sterilized gauze, cotton and roller bandage applied. If the wound be packed too firmly with the iodoform gauze during the first few days following the operation, there is danger of injury of the facial nerve with resulting transient paralysis of some of the facial muscles; later on the wound may with advantage be packed more firmly. In some cases the wound does better if, after thorough cleansing, it be dusted with boric acid, and packed either with sublimate or sterilized gauze. This is more especially the case if the lips of the wound appear sluggish and the exposed bone does not quickly cover itself with granulations. The presence of œdema in the superficial tissues about the wound may render advisable the use of a wet sublimate dressing for from twenty-four to forty-eight hours. Sometimes exuberant granulations on the superficial edges of the wound will require removal with the curette or scissors, as the wound requires to be kept open until firmly healed from the bottom, a result that usually requires from three to four weeks.

Usually recovery from a mastoid operation is uneventful. Pain and sleeplessness on the night following the operation may require the use of a small dose of chloral and bromide of sodium, or even an opiate. Usually the temperature is practically normal and the patient entirely comfortable on the morning following the operation; and if the temperature remain normal for one or two days, he may be allowed to sit up and move about in his room.

Persistent pain and sleeplessness with high temperature following the operation may be due to a slight attack of local periostitis or to the fact that all the foci of inflammation in the mastoid bone have not been reached by the chisel.

What are the intra-cranial complications of disease of the middle ear?

Meningitis; extra-dural, intra-dural, cerebral and cerebellar abscess; thrombosis of the lateral sinus.

What are the symptoms of meningitis complicating disease of middle ear?

Slight cerebral irritation, especially in children, probably meningitis, frequently accompanies acute inflammation of the middle ear. The symptoms are localized headache referred to the temporal or occipital region, which may be tender on percussion. Morning and evening fever is sometimes present, and in children convulsions.

The meninges in aural suppuration are involved as the result of caries of the osseous walls or infected through the numerous vessels that penetrate the bone. The process may be entirely local, a slight pachymeningitis gluing the dura to the bone and preventing the further spread of infection. The disease, however, may affect the entire surface or be confined to the basilar meninges. The temperature is usually from 101° to 105°, and exhibits but slight variation during the day and night. There are severe headache, photophobia, vomiting and localized or general convulsions. Delirium is common in young subjects, but in adults the patient slowly passes into a condition of fatal coma. Paralysis of the pupil, strabismus, and ptosis are the most frequent forms of paralysis present.

What is the treatment?

Where the symptoms are simply those of cerebral irritation, perfect rest in bed, large doses of the bromides, purgation with small, frequently repeated doses of calomel and salines. Sometimes the local abstraction of blood from the ear by means of leeches or Wild's incision and an ice-cap are effectual in checking the attack.

As the disease is invariably fatal unless checked in time, surgical measures to be effectual must be instituted early. Where there is no doubt as to the diagnosis, the mastoid antrum should be opened, and if the amount of disease met with is not sufficient to account for the symptoms, the cranial cavity also, in search of an extra-dural abscess. Even if no pus be found, the opening into the cranium with the consequent local depletion and relief of tension is the best possible treatment and has been followed by recovery in some severe cases.

What is sub-dural or extra-dural abscess?

Sub-dural abscess is a collection of pus between the dura mater and the bone. The most usual sites of sub-dural abscess following aural suppuration are the groove for the lateral sinus and the superior surface of the petrous bone. Such collections of pus can sometimes be located and evacuated by surgical intervention. Cases of spontaneous evacuation through the middle ear have been reported.

What is intra-dural abscess?

A more or less localized collection of pus between the dura and the brain as the result of meningitis. The prognosis is much graver than in extra-dural abscess, as the collection of pus is less definitely located and more difficult to reach.

What are the symptoms of cerebral abscess?

Cerebral abscesses as the result of infection from suppuration of the middle ear are usually located in the temporo-sphenoidal lobe, and generally present but few symptoms for at least several months; but at any moment acute meningitis may occur or increased intracranial pressure result in coma and death.

In the early stages the diagnosis is usually not easy. Severe, deep-seated pain, and tenderness over the temporal region, optic neuritis and localized paralysis may be present to a greater or less degree.

What are the symptoms of cerebellar abscess?

The symptoms are more obscure even than in cerebral abscess, and the diagnosis extremely difficult. Subjects of cerebellar abscess may present absolutely no symptoms, and yet suddenly die as the result of the rupture of the abscess into the fourth ventricle.

What is the treatment?

Surgical interference in all cases of intra-cranial suppuration is the only adequate remedy. As a general rule the cranial cavity should only be entered after removing diseased structures from the middle ear. After the antrum and attic have been cleaned, the original skin-wound is enlarged to a sufficient degree by an incision directly backward and the periosteum detached. The groove for the lateral sinus is then cautiously opened by means of a mallet and chisel and the sinus examined carefully for thrombus. If no clot is found, the opening into the skull is enlarged by means of the trephine, chisel, or cutting-forceps upward to reach the middle or downward to reach the posterior cranial fossa. While proceeding with the operation it is possible that an extra-dural abscess may be opened. Under such circumstances free drainage should be secured and the wound dressed. If no such collection of pus is discovered while enlarging the cranial opening, a flexible grooved director should be passed in different directions between the dura and the skull in search of pus, and finally the tegmen of the antrum and attic removed, as extra-dural abscess is not unfrequently located upon this thin plate of bone.

If cerebral abscess be present near the surface, the dura will bulge without pulsation into the wound. Selecting a spot, a small sterilized hollow needle is carefully inserted into the brain. Should pus escape or the needle yield a fetid odor when withdrawn, the dura is incised and a trocar passed in the required direction. If a definite pus-cavity be emptied of its contents, it should be washed out gently with a warm, sterilized, saturated solution of boric acid, a drainage-tube inserted into the tract of the trocar, the wound closed, and a dressing applied.

If exploration of the middle cranial fossa does not yield results sufficiently definite to account for the symptoms, the wound in the skull is enlarged downward sufficiently to permit access to the structures below the tentorium. The exploration in this region should be conducted on the same general principles as in the middle cranial fossa, but of course the utmost care should be exercised in the use of the exploring needle.

Describe sinus thrombosis.

The lateral sinus may be infected by way of the superior petrosal sinus as the result of attic suppuration. Usually, however, the infection proceeds from the mastoid cells by way of the numerous small veins that reach the sinus through the bone. An early stage of the process is the occlusion of the sinus by a firm fibrinous clot which may extend backward as far as the torcular Herophili or downward into the internal jugular vein. The development of septic bacteria within the clot leads to general septic infection; and if the patient survives long enough, secondary abscesses appear in various organs of the body, septic pneumonia being the most common complication; but it should not be forgotten that sinus thrombosis may produce secondary sinus thrombosis and brain abscess on *the opposite side.* Occasionally sinus phlebitis occurs as the result of the contact of necrosed bone, so that the sinus is easily torn during the mastoid operation, with resulting severe hemorrhage.

What are the symptoms of sinus thrombosis?

The progress of the disease is exceeding insidious, and the symptoms vague. The most reliable is a sudden great rise of temperature, followed by an abrupt fall at successive intervals as the result of the breaking down of a portion of the clot and the passage of septic material into the general circulation. Unless the thermometer be used every two or three hours during the day the characteristic variation in temperature may readily escape notice. In uncomplicated cases intra-cranial symptoms such as severe headache, paralysis or convulsions are absent. Sooner or later symptoms of general sepsis occur—asthenia, emaciation, an ashy hue of the skin, and profuse perspiration. Severe rigors may or may not occur.

A certain number of cases of primary thrombosis recover spontaneously, although it is impossible to state how many die subsequently of secondary cerebral abscess and other sequelæ of the disease.

What is the treatment?

Early operation if the diagnosis is certain. The only therapeutic measures of value are those which combat the asthenia. Nutritious food, by mouth or rectum, large doses of quinine, and alcoholic stimulants.

When the mastoid antrum has been previously opened the original opening should be enlarged backward and downward, and the dura exposed as far as the occipito-temporal suture. After the sinus has been exposed the presence of a clot is determined either by the sense of touch or by inserting a carefully sterilized hypodermic needle. If a thrombus is present, pus or foul-smelling blood are usually withdrawn; but if the channel is normal, fluid blood alone enters the syringe.

To remove an infectious thrombus, the sinus is freely incised and its cavity emptied by the delicate use of a curette until decidedly free hemorrhage supervenes. The cavity should then be packed with iodoform gauze.

When the clot has extended downward into the jugular vein, as evidenced by tenderness along the anterior border of the sterno-cleido-mastoid muscle and a cord-like structure occupying the position of the vein, the vessel should be exposed, laid open between two ligatures, and the clot removed as from the lateral sinus. Any large tributary vein should, however, be tied before dividing the jugular. If the operation is performed before secondary abscess or profound systemic infection has occurred, it may result in the recovery of the patient.

FACIAL PARALYSIS.

What is facial paralysis?

Facial paralysis, or Bell's palsy, is a paralysis or paresis of some or all of the muscles supplied by the facial nerve. In the graver form of the diseases there is complete immobility of the muscles of expression of the affected side of the face, slight deafness from involvement of the stapedius muscle, unilateral paralysis of the uvula and the palate, and unilateral impairment of the sense of taste at the anterior two-thirds of the tongue, through involvement of the chorda tympani nerve.

What is the etiology of facial paralysis?

The disease may be *central*, as the result of basilar meningitis, tumors or exostoses at the base of the brain, syphilitic lesions in this situation, or aneurysm of the vessels at the base of the brain. Not a few cases are apparently rheumatic, and result from exposing one side of the face to a draught, sitting in a damp room, or suddenly chilling the body when overheated. The disease is of interest to the aurist chiefly from the fact that it may occur as a complication in a large variety of middle-ear affections, or as a result of the nerve being bruised or wounded during the course of an operation upon the middle ear, or from packing the wound too tightly after the operation. It should be borne in mind that the facial canal arches backward over the oval window and then descends almost perpendicularly through the temporal bone. As the result of the oblique position of the drum-head, the facial canal approaches in some skulls to within one millimetre of the annulus, at a position about midway between the floor and the roof of the canal. The pressure of a polypus or an accumulation of epithelium or cerumen on the nerve through the thin bone of this region is sufficient in some cases to produce paralysis of the facial nerve, usually remediable by the removal of the offending body. Generally, however, the facial nerve in its passage through the middle ear is defended by comparatively thick and hard bone. In some instances, however, the bone covering the nerve above the oval window is as thin as tissue-paper, and congenital dehiscences of the bone of this region are by no means uncommon, so that the nerve in such cases lies almost immediately under the mucous membrane. Such a congenital lack of bone in this position explains the occasional occurrence of facial paralysis as the result of simple non-suppurative catarrh of the middle ear. Suppuration of the middle ear is a common cause of facial paralysis, sometimes so slight that the lack of mobility of the affected side of the face can be detected only by the closest scrutiny; at other times the paralysis is complete and involves all the muscles supplied by the facial nerve on the affected side of the face. Such cases are doubtless the result of pressure on the nerve caused by spreading of the inflammation from the mucous membrane to the bony wall of the facial canal and the sheath of the nerve, and are the more favorable instances of the disease; for after the subsidence of the inflammation and the absorption of the exudation the facial paralysis disappears spontaneously. Facial paralysis occurs during caries and necrosis of the temporal bone if the inflammation and destruction extend to the nerve; but caries of the facial canal is not always accompanied by paralysis, for instances are on record where, as the result of caries, the nerve has been exposed and bathed in pus for months without the occurrence of facial paralysis. Facial paralysis in more than one instance has followed the simple removal of the drum-head and larger ossicles, and is not uncommon as the result of the mastoid operation. Most of these cases ultimately completely recover, sometimes even when there was reason to suppose that the nerve had been completely severed. When working in the neighborhood of the facial nerve, some operators are in the habit of directing their assistant to watch for slight twitching of the muscles of the face, and desist immediately should this occur. When twitching of the face occurs under these circumstances, it is an indication that mischief has already been done to the nerve, and, unless absolutely necessary, the vicinity of the facial nerve should be studiously avoided during the Stacke and mastoid operations. Many operators are accustomed, when performing Küster's operation, to guard the position of the facial canal with a bent probe or similar device introduced into the tympanum through the opening in the mastoid bone. Doubtless this is a useful procedure in some instances, but the use of the probe in this manner is apt to produce a misleading sense of security, and there are reasons for believing that in some instances the injury to the nerve has been done by the slipping of the probe entrusted to the hand of an assistant rather than by the instrument in the hands of the operator. The wound in the bone after a middle-ear operation should be only lightly packed with gauze, especially in the case of children. The only instance of facial paralysis occurring in the practice of the writer happened two weeks after a mastoid operation, as a result of packing the wound too tightly.

What are the symptoms of facial paralysis ?

Double facial paralysis is somewhat rare. When it does occur and is complete, the face is absolutely expressionless and as immobile as that of a graven image. In a case observed by Tröltsch the cornea was partly dried as the result of ectropion of the lower lid, the under lip hung loosely down, and the chin had to be pushed up in speaking and eating. Facial paralysis sometimes appears quite suddenly, but in many instances there are premonitory symptoms of pain in the side of the head and twitching of the muscles of the side of the face. A patient suffering from complete facial paralysis is unable to wrinkle the brow or close the eyes, although the upper eyelid often descends somewhat during the effort. On account of the paralysis of the orbicularis, the puncta lachrymalia drop away from the globe and the eye is constantly suffused with tears, and, being no longer protected from dust and cold by the motionless lids, soon becomes inflamed. The ala nasi on the affected side cannot be distended during inspiration, and hence nasal respiration and the sense of smell are impaired on the affected side. The angle of the mouth drops a little and is drawn somewhat toward the unaffected side. While drinking, some of the fluid dribbles from the corner of the mouth; and the food collects between the cheek and the teeth, so that it is necessary while eating to remove it from time to time with the finger. If the cheeks are distended, air escapes at the corner of the mouth, and because of the paralysis of the palate-muscles it is usually necessary to employ the Eustachian catheter if the ears require inflation. The hearing is usually somewhat impaired as the result of paralysis of the palate-muscles, but sometimes becomes still worse, if care is not exercised, from Eustachian salpingitis resulting from the paralysis of the tubo-palatine muscles. When an attempt is made to smile, the entire lower part of the patient's face seems to move toward the unaffected side. If recovery does not occur, the affected muscles sometimes undergo atrophy, so that the affected side of the face looks smaller than the other. Contractures and spasms of the affected muscles in some cases finally occur, the spasms being clonic in character and not painful. As the result of contracture the angle of the mouth is sometimes drawn upward and the naso-labial fold deepened until at the first glance it would appear as if the unaffected side of the face were the paralyzed one.

In many instances the paralysis of the facial muscles is not complete, the muscles of the lower portion of the face being the ones most affected. In some instances, however, the muscles of the lower portion of the face and those of the forehead as well will be almost completely paralyzed, while the eye can still be completely shut, although with considerable effort. As this form of paralysis is the most common after middle-ear operations, it would appear that the fibres of the nerve supplying the muscles of the lower part of the face and the forehead occupied a more superficial position within the facial canal than those supplied to the orbicularis palpebrarum.

In facial paralysis what points in diagnosis should be borne in mind?

In the variety of the disease due to a central lesion the paralysis usually occurs after an apoplectic seizure, and other muscles are generally affected besides those of the face. Generally in such cases the muscles of the forehead and the orbicularis palpebrarum are affected to a considerably less degree than those of the other parts of the face, and the electric contractility of the affected muscles is not affected in the slightest degree, no matter how profound the paralysis may be. In a certain proportion of cases the unilateral paralysis of the palate, impairment of the function of taste at the anterior two-thirds of the tongue, and the presence of a disease of the middle ear that is capable of causing a lesion of the seventh nerve are points that will help to clear up the diagnosis. In peripheral facial paralysis it is sometimes possible to determine with a certain amount of accuracy the portion of the seventh nerve in which the legion has occurred. If the lesion is above the geniculate ganglion, there will be paralysis of all the facial muscles, and those of the palate and uvula, with disturbance of hearing: but the sense of taste will be unimpaired, because the chorda tympani nerve enters the facial at the geniculate ganglion. If the lesion is between the geniculate ganglion and the point at which the nerve to the stapedius muscle is given off, there will be paralysis of the facial muscles, disturbance of hearing, and impairment of the sense of taste, but the movements of the soft palate will remain unimpaired, because its motor fibres are supplied from the geniculate ganglion. If the lesion is situated between the point where the stapedius nerve is given off and the point where the chorda tympani leaves the nerve, the former symptoms will be present, with the exception that there will be no disturbance of hearing; and if the lesion is below the point where the chorda leaves the facial nerve, there will simply be paralysis of the muscles of one side of the face. In order that the above should be practical for purposes of diagnosis, it is necessary that the lesion should be sufficiently great to involve all the fibres of the nerve, which, of course, is not always the case.

What is the prognosis?

The prognosis, of course, will depend upon the nature of the lesion producing the facial paralysis. When a portion of the nerve has sloughed away as the result of caries of the temporal bone, recovery from facial paralysis is not to be expected; and where the nerve has been completely divided during a middle-ear operation, complete recovery rarely occurs. Cases of paresis of the facial nerve and cases where only a part of the muscles of the face are involved usually result in complete recovery. The development of contractures and spasm is a most unfortunate event, as no cases where this occurs recover from the facial paralysis; and considerable deformity of the face is usually the result of the contractures and spasms. When the electrical excitability of the nerve and muscles remains unchanged, spontaneous recovery in from three to eight weeks may be expected, providing the middle-ear disease that produced the lesion of the nerve ceases to be an active factor in the case. In many cases the excitability of the nerve and muscles to the faradaic and galvanic currents begins to diminish within a few days of the onset of the paralysis, and is entirely lost at the end of a week or ten days; and this extinction of electric excitability continues until the patient begins to recover. Usually, in such cases, the patient is able to produce voluntary movements of the paralyzed muscles before the nerve begins to react to electric stimuli. The case should not be regarded as hopeless when electrical excitability of the affected muscles is entirely lost for a short period; but such cases make a tedious recovery, and a period of from six to nine months usually elapses before a cure of the paralysis occurs.

What is the treatment?

If diseased, the middle ear should of course receive appropriate local treatment. In rheumatic cases and those resulting from disease of the middle ear it is well to place the patient upon full doses of iodide of potassium and an ointment of equal parts of mercurial, iodine, and belladonna ointments should be rubbed into the skin over the mastoid and below the ear sufficiently often to keep the parts slightly sore to the touch. After from one to three weeks have elapsed and reaction has set in, it is well to begin the use of electricity, preferably the faradic current, to the affected muscles, but in some cases better results are obtained from the employment of the galvanic current. A weak galvanic current may be sent along the affected nerve-trunk by placing a medium-sized electrode over each ear (the negative on the affected side), and passing a current between them. The faradic current may be applied to the affected muscles by placing a small electrode over them in turn; or the electrode may be passed along a line in front of the auricle in order to reach the fibres of the pes anserinus where they cross the side of the face. The current should be of sufficient strength to produce contractions of the affected muscles, and the sittings should last not longer than ten minutes every day or every other day.

DISEASES OF THE PERCEPTIVE APPARATUS.

How is a diagnosis made between middle ear-deafness and that resulting from disease of the internal ear?

The diagnosis is made from the history of the case and by means of tuning-forks. Sudden deafness without pain is usually the result of impacted cerumen or of disease of the receptive apparatus of the ear. In most cases of long-continued disease of the middle ear the functions of the labyrinth become impaired because of the extension of the disease into the vestibule. It should be borne in mind that there are a few very short rods at the commencement of Corti's organ near the vestibule, and that these rods are set in vibration by high-pitched sounds. Hence when disease of the middle ear has extended from the middle ear into the labyrinth, hearing is greatly impaired for high-pitched notes.

A vibrating tuning-fork with its handle upon the mastoid is heard *longer* in middle-ear disease than if the middle ear were normal. If, however, the functions of the labyrinth are impaired, the reverse is the case. A vibrating tuning-fork with its handle upon the vertex or forehead is heard best in the deafer ear in cases where the functions of the receptive apparatus are unimpaired (Weber's method). The sound of a vibrating tuning-fork is heard longer when its tines are at the auditory meatus than when the handle is pressed upon the mastoid (Rinne's test, positive) by normal ears and by ears in which deafness is mainly the result of impairment of the functions of the receptive apparatus. Rinne's test is negative in cases where the deafness is due to impacted cerumen or disease of the middle ear.

It must not be supposed that tests with the tuning-fork are infallible; for example, in cases in which the capsular ligament around the stapedio-vestibular-joint has become stiff as the result of disease, it is easy to understand how the stapes can become fixed in the oval window as the result of a blow on the side of the head or the concussion produced by the unexpected discharge of firearms. Under such circumstances suspension of the function of hearing will result from suddenly-increased interlabyrinthine pressure. The symptoms under such circumstances would all point toward disease of the labyrinth, and yet the hearing may become nearly normal as the result of vigorous inflation of the middle ear by Politzer's method. It is evident that in a case of this kind there was no actual disease of the labyrinth.

What are the symptoms of concussion of the labyrinth?

Sudden deafness following concussion or a blow, without visible local injury. Tinnitus is usually present. The prognosis is unfavorable, but $\frac{1}{16}$ to $\frac{1}{8}$ of a grain of pilocarpine should be injected subcutaneously each day until symptoms of weakness of the patient occur or it is manifest that the treatment is unavailing.

What is hysterical deafness?

Hysterical deafness is a somewhat rare symptom occurring in hysterical women. The deafness may be complete, lasting for several hours or days. Treatment is the same as for other hysterical conditions.

How is the internal ear affected by syphilis?

Plastic exudations may occur within the labyrinth similar to those occurring in plastic iritis. The disease is ushered in by loud subjective noises, deafness soon following. There is usually a noticeable disturbance of the patient's gait, and he complains of constant dizziness. The prognosis is not altogether unfavorable if vigorous antisyphilitic treatment is begun early.

What is the significance of a discharge of blood from the internal ear?

Occurring after traumatism, as it invariably does, a discharge of blood from the internal ear indicates fracture of the base of the skull. An effusion of blood may occur within the labyrinth and cause complete disintegration of this organ.

What is Ménière's disease?

"Ménière's disease" is a name given to a group of symptoms which may be caused by various affections of the labyrinth, the acoustic nerve, or the central nervous system, usually apoplectiform in character. There are sudden loss of hearing, tinnitus, and vertigo to such a degree often that the patient is unable to maintain his balance and falls to the ground.

Usually the more alarming symptoms pass away within a few days, leaving, however, some deafness, tinnitus, and vertigo, which may remain for years, the deafness gradually getting worse until it is complete.

What is the treatment?

After the subsidence of acute symptoms iodide of potassium may be administered in doses of from 5 to 15 grains three times a day, and compound iodine ointment may be rubbed into the tissues about the ear. A hypodermic injection of pilocarpine, $\frac{1}{16}$ to $\frac{1}{12}$ of a grain, should be given each day. It should be borne in mind that the use of this drug is not unattended by danger, and inhalations of ammonia or the administration of a stimulant may be necessary during the sweating stage to maintain the heart's action.

Quinine, in small doses three times a day, is recommended by some authorities, the statement being that its use at first *increases* the disagreeable symptoms, but is followed by their amelioration.

What other diseases occur in the labyrinth?

Metastasis may occur in parotitis or mumps to the labyrinth, with an exudation of a plastic material, the symptoms being deafness, tinnitus, and vertigo. If the affection is treated early, before the organization of the plastic material, with hypodermic injections of pilocarpine, the prognosis is not altogether unfavorable.

Politzer and Voltolini have described primary acute labyrinthitis, but this affection is very rare. Panotitis as the result of scarlatina, diphtheria, or variola is not so very uncommon. The affection, which generally begins as an acute inflammation of the middle ear, extends to the labyrinth, or both parts of the ear may be attacked simultaneously. The course of the disease is very rapid, and it ends in complete destruction of the organ of hearing. Its sequelæ may be caries of the bone and chronic suppuration of the middle ear.

When the affection begins, as it generally does, as a purulent inflammation of the middle ear, vigorous treatment by means of antiseptic injections, the use of powdered boracic acid, and other suitable measures will usually control the severity of the inflammatory process before the labyrinth is involved.

FORMULÆ.

1. Sodii bicarbonatis, Sodii biboratis,	āā ʒj.
Acidi carbolici	gr. xv.
Glycerini	f℥j.
Aquæ	q. s. f℥iv.—M.

Sig.—Add to a quart of water and use as a wash for the nose and throat.

The above wash, which is a modification of the celebrated "Dobell's solution," is entirely bland and unirritating to mucous membranes. It may be used either as a spray to cleanse the mucous membranes of the nose and throat, or may be prescribed as a wash for the patient's use at home. When used as a nose-wash by the patient it should be at a temperature of about 100° Fahrenheit.

2. Sodii bicarbonatis, Sodii biboratis,	āā ʒj.
Sodii salicylatis	gr. iij.
Menthol, Thymol,	āā gr. j.
Glycerini	f℥j.
Aquæ torrid.	q. s. f℥iv.—M.

Sig.—Dilute with 7 parts of water, and use as a spray or wash for the nose and throat.

The above wash, which is similar in its therapeutic action to Dobell's solution, is free from the odor of carbolic acid that is so very disagreeable to some individuals. Both washes are sufficiently alkaline to soften and dissolve mucus. They are entirely bland and unirritating to mucous surfaces, as the result, partly, of their specific gravity, being about 1.020, like that of the tears, the urine, and some other normal secretions. A wash either much above or below a specific gravity of 1.020 will be irritating from this fact alone, regardless of its composition. In cases of atrophic rhinitis, where it is desirable to increase exosmosis, the wash should be used more concentrated than in chronic and in hypertrophic rhinitis.

3. Listerine	f℥iij–vj.
Aquæ	Oij.

Useful as a disinfectant and irritating wash in atrophic rhinitis.

4. Fluid cosmoline ("O.")

May be used with the atomizer and applied to the nasal mucous membrane as a protective.

5. Fluid alboline.

Many of the bleached or white-fluid cosmolines for sale in the market are bland and unirritating, while others are very irritating to sensitive mucous membranes. The surgeon should assure himself of the bland and unirritating qualities of such preparations before using them in his office practice or prescribing them for the use of his patients. Certain gums and camphors nearly insoluble in water may be dissolved in fluid cosmoline or alboline and used with advantage as applications to mucous membranes. Probably the most useful of such substances are menthol and camphor.

6. Fluid alboline . . . . ℥j.
Camphor . . . . gr. x.—M.
Make a solution.
Sig.—Use with an atomizer.

The above solution of camphor in alboline is sedative and slightly astringent.

7. Fluid alboline . . . . ℥j.
Menthol . . . . gr. x.—M.
Sig.—Use with an atomizer.

A solution of menthol in oil of the above strength, when applied to the nasal mucous membrane, produces at first a sensation of irritation, followed by decided sedative effects and a sensation of cold. Its analgesic properties in acute coryza are decided. Frontal headache as the result of a cold in the head is promptly relieved by spraying the nasal mucous membrane with the above formula.

8. Solution of the hydrochlorate of cocaine, 4 per cent.

The local anæsthesia produced by the application of a 4 per cent. solution of cocaine to the nasal mucous membrane, although later in making its appearance, is more profound and enduring than if a stronger solution were employed. This is probably due to the fact that contraction of the superficial blood-vessels, occurring almost immediately when a strong solution of cocaine is applied to the nasal mucous membrane, greatly interferes with its further absorption. When it is desired to produce local anæsthesia of any portion of the interior of the nose for the purpose of operation, a piece of absorbent cotton should be saturated with the cocaine solution and laid in contact with that part of the nose where the anæsthesia is desired, and after the lapse of a few moments the sensibility of the parts should be tested with a probe; if anæsthesia has not been produced, the piece of absorbent cotton should again be dipped in the solution of cocaine and replaced within the nose. Anæsthesia of the tympanic mucous membrane may be produced in the same manner, or a few drops of a 4 per cent. solution of cocaine may be injected into the tympanum by means of a syringe. Watery solutions are not absorbed with sufficient facility by the skin to render their use inside the auditory canal at all satisfactory for producing local anæsthesia. Diminished sensibility of the drum-head and of the walls of the canal may, however, be secured by rubbing well into the skin of the parts a 10 per cent. ointment of cocaine in lanolin.

9. Antipyrine	gr. x–xxx.
Aquæ	f℥j.

A solution of antipyrine of 2 to 4 per cent. strength, when sprayed upon the mucous membrane of the nose or pharynx, has the power of contracting the capillaries and of producing an artificial anæmia, which effect is maintained for from three to five hours. Solutions of antipyrine may be used with the atomizer in all acute inflammations of the mucous membrane of the upper respiratory tract. When used after the application of cocaine to the interior of the nose, a 4 per cent. solution will maintain the contractile effect of cocaine upon the erectile tissue for several hours. When sprayed upon the nasal mucous membrane without the previous application of cocaine, a 4 per cent. solution gives rise to a smarting sensation, which, however, quickly subsides. Antipyrine solutions of the proper concentration applied to mucous membranes produce analgesia, but not local anæsthesia.

10. Solution of peroxide of hydrogen, 15 volumes.

It is usually important that the peroxide of hydrogen applied to the mucous membrane of the nose, pharynx, or tympanum should be as unirritating as possible. Many of the preparations sold in the market are irritating to mucous membranes, because of the free acid which they contain. While the presence of an acid is said to increase the antiseptic properties of the drug for certain purposes, it renders the solution nearly unfit for use inside the nose, but more especially for use within the tympanum. A 15-volume solution of peroxide of hydrogen of neutral reaction may be injected into the tympanum with impunity if there be a sufficiently large opening through the drum-head to permit of the ready exit of the large quantity of foaming material immediately produced by its contact with pus. Peroxide of hydrogen may also be applied by a cotton-tipped probe to any accessible part of the middle ear, in order to loosen inspissated pus and cholesteatomatous masses. For this purpose stronger than 15-volume solutions are sometimes convenient. A 15-volume solution may be concentrated to any desired strength up to a 100-volume solution by rapidly evaporating it in a shallow dish at a temperature just below the boiling-point. Under these circumstances the water of the solution is evaporated much more quickly than the peroxide is decomposed.

11. Iodini	gr. x.
Kalii iodidi	ʒss.
Glycerini	f℥j.—M.

12. Boroglyceridi	℥j.
Glycerini (anhydrid)	℥j.—M.

Pulverize the boroglyceride in a mortar and dissolve in the hot anhydrous glycerin. 50 per cent. boroglyceride, made in this manner, is less irritating than that for sale in the drug-stores.

13. Acidi tannici	gr. xl.
Glycerini	f℥j.—M.

Solve.

The above solutions are useful applications to the mucous membrane of the nose and pharynx. The compound iodine solution is especially useful in catarrh of children, in whom the adenoid structures bear the brunt of the inflammation. Applied inside the crypts of the tonsils by means of a cotton-tipped probe bent at a right angle, it often brings about a rapid absorption of the hypertrophied glands. Either of the other solutions may be applied by means of a suitable cotton-tipped probe to the mucous membrane of the nose or naso-pharynx.

14. Alcohol absoluti.

Useful as an application to the tympanic mucous membrane when it is covered by granulations and small polypi. For the patient's use at home, to cause shrinking of granulations and polypi, absolute alcohol, diluted with an equal amount of water, may be prescribed, to be dropped into the auditory canal several times a day. Boric acid dissolved in alcohol may also be prescribed for use in the same manner.

15. Pulvis acidi borici.

It is absolutely necessary that the powdered boric acid, insufflated within the tympanum as an application in the treatment of purulent inflammation, should be impalpable and free from all grit, as the sharp-pointed crystals of this substance are extremely irritating. A good plan is to test the powdered boric acid by rubbing a small quantity upon the lip with the tip of a finger, rejecting as unfit for use inside the ear those specimens that are "gritty."

It is important also that too large a quantity of boric acid should not be thrown into the ear at one time, or it may form a hard mass, and thus prevent the escape of discharges. This is less likely to occur if the powdered boric acid be triturated with tincture of calendula officinalis, as advised by Sexton.

The following powders are of use in the treatment of otorrhœa:

16. Chinolini salicylatis	ʒss–ʒj.
Pulvis acidi borici	℥j.
	(Burnett)
17. Aluminii	gr. x.
Pulvis acidi borici	℥j.
18. Iodoformi	ʒj.
Pulvis acidi borici	℥j.

19. Unguenti hydrargyri,
Unguenti iodini } . . . . āā ʒj.—M.

Useful as an inunction over the mastoid in commencing mastoiditis, and as an inunction over hypertrophied lymphatic glands about the angle of the jaw.

20. Unguenti hydrargyri,
Unguenti iodini
Unguenti belladonnæ, } . . . . āā ʒj.—M.

Useful as an inunction within the auditory canal in furunculus and diffuse inflammation.

21. Hydrargyri oxidi flavi . . . . gr. ij.
Petrolati . . . . ʒiij.—M.

Useful as an application in eczema of the auricle after all scabs and crusts have been removed by means of peroxide of hydrogen. This ointment should be well rubbed into the inflamed tissues, and a single application is sometimes sufficient to bring about a cure if care be exercised that purulent discharges from the tympanum are not allowed to come into contact with the skin of the auricle.

22. Chloroformi.

23. Iodini.

24. Tincturæ iodini . . . . f ʒj.
Æther . . . . f ℥j.—M.

25. Menthol.

The vapor of these substances is sometimes used as an application to the mucous membrane of the middle ear. They should be preserved ready for use in wide-mouthed, glass-stoppered bottles, so that the Politzer air-bag can be filled with their vapor by placing the nozzle of the bag within the neck of the bottle while the bag is expanding. Ether and chloroform vapor will sometimes penetrate into the middle ear through the Eustachian tube when it is impossible to inflate the middle ear with simple air by Politzer's method or the use of the catheter.

26. **Contractile collodion.**

Contractile collodion is sometimes applied to a cicatrix or atrophic drum-head to hold it in a favorable position for hearing. For this purpose only a small amount of the collodion should be painted upon the drum-head at one time, as there is some danger of producing myringitis from the injudicious use of the remedy.

27. **Phosphorated oil.**

Formerly many ointments and solutions were applied to the membrana tympani for the relief of tinnitus and deafness caused by catarrh of the middle ear. Although this form of medication has largely been abandoned, phosphorus dissolved in olive oil, if applied to the drum-head, will sometimes bring about improvement of the hearing in deafness due to senility.

28. Atropiæ sulphatis	gr. iv.
Morphiæ sulphatis	ʒj.
Aquæ	f ℥j.

One or two drops may be applied inside the auditory canal for relief of the pain incident to acute inflammation of the middle ear and myringitis.

29. Argenti nitratis	ʒj–ij.
Aquæ	f ℥j.—M.

May be used as a sedative application in granular inflammation of the tympanum, a small amount being painted upon the parts by means of a dossil of absorbent cotton.

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